CONGENITAL DISLOCATION *of* THE HIP

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PREFACE

CONGENITAL DISLOCATION OF THE HIP HAS ALWAYS PRESENTED an unique problem in Orthopedic Surgery Orthopedic surgeons have been baffled not only by the mystery of its origin, but also by its unpredictable course and the uncertainty of results of treatment.

The launching of a monograph on congenital dislocation of the hip at this time requires some justification It is now 50 years since the first discovery of an effective treatment for this condition A vast amount of work has been expended upon the study of the deformity, nevertheless, no complete accord has been reached as to the best method of treatment to be employed Orthopedic surgeons here and abroad differ in their opinions with regard to the advantages of open and closed reduction Some favor open reduction exclusively, while others believe that closed reduction should be given preference and reserve open reduction for those cases only in which closed reduction has failed Nor is there any unanimity with regard to the after-treatment, and particularly in the estimation of the actual efficacy of treatment. As with so many other modalities in medicine, however, time and experience have tempered our judgments and have finally led to the development of a more rational scheme of therapy

The last collective treatise contributed by Adolf Lorenz, and which has served as a helpful foundation for the present book, was published in 1920 It is obvious that the concepts of this work, which were true in the long past, could not apply to the more modern views of today

In the present study, an attempt is made to appraise the recent theories and methods of treatment for congenital dislocation of the hip and to clarify some of the pending problems.

The association with Lorenz for so many years, and the personal experience as his successor at the Orthopedic University Clinic of Vienna, justifies the author in offering an organized preparation of his own observations based on a series of more than

2,000 cases of Congenital Dislocation of the Hip Although a definite effort has been made to mediate most of the controversial points he has not hesitated to express his own convictions freely

In view of the almost boundless literature that has accumulated on the subject, the author was forced to limit his references chiefly to the original reports of the last 25 years For some inevitable shortcomings, he begs for leniency

I am greatly indebted to Dr Philip D Wilson, Surgeon in Chief of the Hospital for Special Surgery, in New York City, for his permission to study several interesting cases from the Orthopedic service of the Hospital. I wish also to express my sincere thanks to Dr John R. Cobb and Dr Frederick vom Sa who have supplied me with clinical details of cases under their car

New York, N Y

JULIUS HASS M D

CONTENTS

CONGENITAL DISLOCATION *of* THE HIP

Chapter I

HISTORY

As WITH SO MANY OTHER CLINICAL PICTURES, OUR KNOWLedge of congenital dislocation of the hip (C D H) can be traced back to Hippocrates. We are indebted to him for the first classic description of this condition with all its distinguishing characteristics, including distortion of the hip, the pathologic gait, the exaggerated lordosis, etc. His prognosis in this "luxation of early childhood" appeared to be unfavorable, however, since he considered its victims suited only for a sedentary life. In the succeeding centuries, the problem of C D H received little or no attention it was taken for granted that the condition was incurable.

It was not until 1701, that Verduc published his more thorough study of the disease picture, dealing also with other interesting aspects. He had, in fact, succeeded in replacing the femoral head in the socket by traction on the thigh in the cadaver As soon as traction was discontinued, however, the femoral head moved irresistably upward as before Thus Verduc was the first to experience the peculiar difficulties of fixation, which continued to resist all therapeutic efforts for another two centuries. Further reports are lacking and it seems that the knowledge attained by Verduc passed once more into oblivion

Even in the famous book of the Eighteenth Century, *L'Orthopédie ou l'art de prévenir et corriger dans les enfants les difformités du corps, etc*" by M Andry (1743), the information on congenital dislocation of the hip is very meager, although Andry did differentiate between cases of dislocation of the hip due to illness and those due to a natural malformation In the latter he found treatment to be of no avail He mentions the remarkable case of a young woman with unilateral dislocation of the hip, who gave birth to six children including three boys with dislocation of the hip, and three girls with normal hips.

This could easily have suggested to him the possibility of hereditary factors of etiologic significance. In 1788, Paletta a noted physician of Milano reported for the first time an autopsy of an 11 year old boy with bilateral dislocation of the hips, and tried to demonstrate that this condition could not possibly have occurred during delivery, but must be the result of a "*vitium primae formationis*"

In 1826, Dupuytren published an excellent treatise entitled *Memoir sur un déplacement original ou congéntial de la tête des fémurs*, presenting a comprehensive picture of this ailment not only from an anatomic pathologic, but also from a clinical and therapeutic point of view His influence, however, was hardly encouraging since he denied any possibility of cure and deplored any attempt at treatment Nevertheless the ensuing years witnessed earnest efforts to conquer this problem of the dislocated hip Thus, in the late eighteen-thirties, Humbert and Jacquier proposed a new plan of treatment They claimed that they were able to effect an immediate reduction, and to maintain the head in the socket To achieve this goal Humbert employed forcible *instrumental* extension By means of the latter he attempted reduction in *one* sitting in a girl of 11 years. Bearing in mind the prevailing technical equipment, and in particular the lack of anesthesia at that time, it is not surprising that his report met with general skepticism.

While we cannot deny Humbert recognition as the origiator of the idea of radical treatment, we are indebted to Pravaz (1838) for being the first to achieve an actually successful reduction by his *gradual* method He subjected his patients to an eight to 10 months period of traction, which can even now be considered as standard. As soon as the femoral head descended to the acetabular level he would start the actual reduction maneuver This consisted in exaggerated extension with simultaneous abduction of the limb and pressure directed medially against the trochanter This maneuver was repeated daily with inexhaustible patience until reduction was finally accomplished He then tried to maintain this reduction permanently by the use of continuous pressure against the trochanter with a pelotte (pressure pad) The glory therefore of being the

:o achieve an actual reduction, belongs incontestably to z However, owing to inadequate fixation his beautiful diate results were lost

ie introduction of anesthesia in 1848, had no influence oever on the development of treatment. Attempts by ican orthopedists, such as Buckminster-Brown, Adams, n, Sayre, Bradford Taylor, Phelps and others, to revive the z method, likewise met with little success.

seeking to explain the complete failure of every attempt atment in those days, it is now clearly evident that one e primary causes of failure was the fact, that for some ceivable reason, only *late* cases were selected for treat- It might have been that they were reluctant to expose ts to operative treatment, or what was more likely that ondition was simply unrecognized in infancy Another s significant cause for failure lay in the entirely unsatis- ry methods of *maintaining* reduction, so that even a suc- il reduction was rendered illusory

was only in the 1880 s that a more active interest in opera- therapy was aroused In 1888, Poggi, at open operation, eded for the first time in reducing the head and fixing it surgically deepened socket. This attempt, however, re- ed an isolated and unrecognized one. Hoffa (1890) fol- l up Poggi's work and obtained a series of remarkably good s. Lorenz improved on the method by contributing a suitable surgical approach. The Hoffa-Lorenz method ted for a time as the preferred one. Nevertheless, because e hazards involved by a cutting operation at that time, it iot enjoy general acceptance.

1 1895, with his long and intensive experience in open re- on, as a starting point, Lorenz established a new, decidedly *rvative* method of treatment. His process involved a com- separation of the two objectives to be fulfilled, namely *ction* and *retention* Insofar as reduction was concerned was undertaken at *one* sitting under general anesthesia by is of a special maneuver.

o retain this reduction, he conceived the notion of fixing ip for a specific and prolonged period in a carefully chosen

primary position" of 90 flexion and 90° abduction by forcibly *maintaining the head in its normal location* Lorenz proceeded rather on the premise that if the femoral head were retained exactly in this position for a sufficient period of time, it would exert a formative influence or stimulus on the cartilaginous acetabulum in its stage of intensive growth. It would thus favor the development of the inadequate socket, if not to a normal status, at least to a degree insuring permanent retention of the femoral head

Just how little credence Lorenz s concept enjoyed with his contemporaries may be gathered from the unfavorable comment of von Bergmann, *whom Lorenz explicitly mentions in* his biography Von Bergmann, a petty dictator, occupying the throne of surgery in the Germany of those days, ridiculed Lorenz s discovery asserting that it was childish to assume that a socket could appear where none had existed and that a stable joint could develop Just how far from the truth von Bergmann was in his assertion was demonstrated in later years by the brilliant results obtained Few medical achievements have enjoyed more complete vindication. And even if those proofs were insufficient in the pre-roentgen era, surely the study of *post-mortem specimens,* when available, should have taught the opposition that if a socket could develop at an abnormal site, it would be so much more likely to develop at the physiological location.

Even later there were sharp attacks challenging Lorenz's contribution and attempts to prove that Paci was the real discoverer of the method As a matter of fact, Paci, in 1888, was the first to obtain closed reduction in *one* sitting, (by the same leveling maneuvers used for reduction of traumatic dislocations,) but the second no less important part of the treatment, namely retention eluded him completely Recognition of the significance of this part of the treatment must be incontestably accredited to Lorenz It was only by a systematic application of reduction *and* retention that the treatment of C D H became a rational

method, without which the desired and attained curative results could never have been realized.

In the past 50 years, still further important advances have been made in the treatment of C D H, to which the present volume shall bear testimony

Chapter II

FREQUENCY AND OCCURRENCE

CONGENITAL DISLOCATION OF THE HIP IS BY FAR THE MOST common of all congenital malformations According to the statistics of Lorenz, which covered the period from 1906 to 1917 the total number of cases of C D H at the Orthopedic University Clinic of Vienna was 1,635 During the same period there appeared 562 cases of congenital club foot, and 238 cases of congenital torticollis Other congenital deformities more rarely encountered were not mentioned. From these statistics, one may conclude that C D H *is three times as frequent as congenital club foot and six times as frequent as congenital torticollis*

In other smaller statistical surveys these ratios differ somewhat. Thus Sangiorgio reported 270 cases of C D H in a series of 323 congenital deformities. Le Damany found 206 cases of C D H as compared with 16 cases of congenital club foot, and 21 cases of hare lip In 100 orthopedic cases Gaugele counted only three cases of C D H

A census of crippled children in Germany in 1907 revealed 75 000 cases, of which about 8 000 were C D H

Congenital dislocation of the hip is much more common in females than in males. Of the 1635 cases reported by Lorenz the sex incidence was

Males	249	15 23 per cent
Females	1386	84.77 per cent
	1635	100 00 per cent

In 1362 cases collected in Germany by Hoffa the corresponding figures were

Males	173	12 70 per cent
Females	1189	87 30 per cent
	1362	100 00 per cent

In 1801 cases from the records of the Hospital for Ruptured and Crippled in New York, reported by Royal Whitman, we find the ratio to be as follows

Males	146	18 35 per cent
Females	655	81 65 per cent
	801	100 00 per cent

From these statistics one could not be wrong in estimating that *the female sex is therefore involved almost six times as frequently as the male.*

As regards the *side* of displacement, it has been demonstrated that C D H is more often unilateral than bilateral

Lorenz	Right hip	462	28 26 per cent
	Left hip	589	36 02 per cent
	Both hips	584	35 72 per cent
		1635	100 00 per cent
Hoffa	Right hip	392	28 78 per cent
	Left hip	468	34 36 per cent
	Both hips	502	36 86 per cent
		1362	100 00 per cent
Whitman	Right hip	206	26 07 per cent
	Left hip	353	44 69 per cent
	Both hips	231	29 24 per cent
		790	100 00 per cent
	Not specified	11	
		801	

According to these statistics, *unilateral dislocation* would therefore, be nearly *twice as common as bilateral dislocation*

The above mentioned statistics of Lorenz, Hoffa and Whitman are now of course, a matter of history, but they are in general agreement with modern statistics.

In an investigation undertaken at my instigation by Scheller (1924) at the Clinic in Vienna, and which included a period of

23 years, i.e., from 1901 to 1923, the following figures were listed In a series of 4 664 congenital deformities, 2 138 cases of C D H were found Of these 2 138 cases, 290 or 13 56 per cent were males, and 1 848 cases, or 86 44 per cent were females The sex ratio of males to females, therefore, was 1 6 37 Of the disloca tions, 1,398 or 65 3 per cent were unilateral, and 740 or 34 61 per cent bilateral corresponding to a ratio of 1.75 1 In the unilateral dislocations, 629, or 29 42 per cent were on the right hip and 769 or 35 96 per cent were on the left hip The ratio of right side to left side involvement was 1 1 22

Of great interest are the statistics of Italian writers, since they have at their disposal the largest hitherto known material.

Thus Scaglietti in a comprehensive study of 3,216 cases recorded at the Istituto Rizzoli in Bologna in the years 1899 to 1931, with 4 692 dislocations of the hip found that 15 27 per cent of these were in males, and 84.73 per cent were in females The ratio of males to females was therefore, 1 5 54 In this series, 54 1 per cent of the dislocations were unilateral, and 45 9 per cent bilateral or a ratio of 1 17 1 In the unilateral cases, the ratio of incidence of left as compared to right sided involvement, was 1 1 64 The incidence of females in the bilateral cases was 4 89 per cent higher than that in the males Dislocations of the right side occurred in 34 32 per cent of the males and in 33 39 per cent of the females. Dislocation of the left side occurred in 23 42 per cent of the males and in 19 96 per cent of the females

Poli reported 8 610 cases observed during the years 1903 to 1936 at the Orthopedic Institute in Milano Of these 8 610 cases, 8 196 were frank dislocations and 414 subluxations. In the series of frank dislocations 1 277 dislocations, or 15 64 per cent were in males and 6 919 or 84 36 per cent were in females, thus showing a ratio of males to females of 1 5 39 Unilateral dislocations occurred in 4,960 cases, or 60 89 per cent and bilateral dislocations in 3 236 or 39 11 per cent The ratio of unilateral to bilateral cases was, therefore 1 55 1 In this series the right side was most frequently involved the ratio of left side to right side being 1 3 37

In a synoptical table, summarizing the statistics of various Italian German and American clinics, and including 37 503 cases of C D H, Poli presents the following figures

Males	5598	14 66 per cent
Females	31905	85 34 per cent
	37503	100 00 per cent

The ratio of male to female incidence was, therefore, 1 5 69
With regard to laterality, the figures were

Right hip	8884	23 69 per cent
Left hip	14011	37 36 per cent
Both hips	14608	38 95 per cent
	37503	100 00 per cent

Thus, in the total number of cases, the ratio of unilateral to bilateral cases was 1 96 1, and the ratio of right to left involvement was 1 1 57

As regards the incidence of unilateral and bilateral dislocations, in our experience, a definite distinction between unilateral and bilateral dislocation is very difficult. For unquestionably all unilateral dislocations have a bilateral 'anlage, and may under certain circumstances, later develop into bilateral dislocations This appears quite clearly in the statistics of Hilgenreiner

Hilgenreiner estimated in a series of 256 cases, including 157 early cases (under one year of age), that the ratio of unilateral to bilateral dislocations was 1 1 18, thus showing a slight preponderance of cases of *bilateral* dislocation This ratio pertained to cases in infancy as well as to the older cases, and these results were probably attributable to the fact that Hilgenreiner included as bilateral dislocations cases with even slight changes on the non-dislocated side. It is safe to assume, therefore, that many cases reckoned in the older statistics as unilateral, would on more careful examination of the normal side, have turned out to be bilateral.

As regards the incidence of involvement of the right side as compared with the left side it appears that the *left side is*

more frequently affected than the right side, and it is generally emphasized that in bilateral cases, the dislocation is frequently more marked on the left side than on the right The reason for this peculiar distribution is not quite apparent Schneider expresses the opinion that the cause is to be sought in the so-called "right-left-problem It has long been a known fact that the right side of the pelvis exceeds the left side in volume and extent (Hasse) For this reason, the thought cannot be dismissed, that in the presence of a congenital disposition to dislocation, the left hip, even normally somewhat handicapped by nature, would be more frequently affected than the right hip Sex has evidently no influence on laterality It seems very probable that coincidence plays a part.

It is most interesting to note a certain *geographic* distribution of C.D.H., with a very high incidence in certain countries and regions, whereas in other places, only very few or no cases whatsoever are observed. A relatively high incidence of this malformation was reported in Tyrol by Albert, in Holland by Korteweg and in certain regions in Germany by Gaugele. On the other hand according to a report by Francillon, C D H is very rarely encountered in Switzerland Le Damany mentions dislocation nests" in the southwestern part of Britanny In cities like Paris, dislocation is three times as rare as in the country Le Damany attributes this to the fact that persons afflicted with dislocation of the hip do not like to come to the city but remain in the country and bequeath it to their progeny The extraordinary frequency of C D H in northern Italy is well known In many of the provinces in this country as for instance in the province of Varese the incidence of C D H according to Poli is up to 2 76 per mille and in some villages up to 19 per mille of the population It is worthy of note that the localities with the highest incidence of C D H in Italy, are found in regions corresponding to the mountain valleys of the pre Alpine region

Le Damany sought the explanation of this irregular distribution of C D H in the anthropologic position of the different *races*, in their respectively different pelvic conformation and related differences in predisposition to dislocation of the hips.

An investigation conducted under his supervision in the French colonies, revealed an extraordinary *scarcity of dislocation in the colored races* It is very rare in the yellow race and almost unknown in the Negro race (not a single case was found in a study of 40,000 Negroes of the Sudan)

Whether CDH is actually as rare in the colored races as asserted by Le Damany, will require confirmation by further statistical studies In the United States, in any case the relative immunity of the black race to CDH appears quite striking In 1921, Baer estimated the ratio to be about one colored child with CDH to every 30 children of the white race thus afflicted. As regards the yellow race, Engel has confirmed the great scarcity of cases of CDH in China, having observed only a single case during his eight-year sojourn in Shanghai. Pelvimetry has revealed that there are no such marked differences in the pelvic measurements of the Chinese as compared with the Europeans, as could explain the frequency of CDH in Europeans and its scarcity in the Chinese. The latter is also clearly demonstrated in the statistics of the well organized Orthopedic Department of the Peking Union College, the annual report of which discloses only a single case of CDH In Japan however which also was long considered as being free from CDH, the incidence of this deformity has increased considerably since the attention of Japanese physicians was drawn to the condition by the works of Hayashi and Matsuoka

At any rate, from all that is known regarding the distribution of CDH, it seems probable that CDH may be governed by certain racial factors, and it seems plausible that the tendency toward malformation or its exemption may be just as dependent upon a racial gene, as are the yellow skin and peculiar eyes of the Chinese, or the black skin of the Negro

A much more difficult problem confronts us in attempting to explain the irregular distribution of CDH in the European population with its intricately ramifying and confused ethnographic conditions. According to M. Lange, increased incidence of CDH is due to crossing of racial pecularities and is particularly noticeable along the border lines of Germany, where different races live in close proximity Gaugele is of

the opinion that races with relatively broad pelves, as for instance the Slavs, show a special tendency to C D H This would explain the high incidence of C D H in Saxony and Thuringia where the population is heavily intermixed with Slavs. In opposition to this theory, however, the statistics of Sonnenschein show a high incidence of C D H exactly in those parts of Austria in which very little of the slavic element is demonstrable.

Poli attributes the high incidence of C D H in the northern provinces of Italy to the high incidence of consanguinity among the people of this region. It seems plausible that more consanguineous marriages would be contracted in communities bound to the land than elsewhere and that certain stigmata such as C D H, rendered recessive through generations, would also become manifest in hitherto unaffected families

Whether miscegenation or consanguinity is responsible for the dissemination of C D H in many regions is uncertain It will be left for future heredobiologic investigations to center interest on areas of highest incidence of this disease.

Chapter III

CLASSIFICATION AND NOMENCLATURE

A GREAT ADVANCE IN OUR KNOWLEDGE OF THE NATURE OF C D H was the recognition of the fact that so called congenital dislocation of the hip is not, as was formerly assumed, actually congenital, but only a disturbance of osseous development defined as *dysplasia*, and characterized chiefly by a flat acetabular roof and underdevelopment of the coxal end of the femur (Figs. 1 and 2)

Even Lorenz, in his classical treatise (1920), uses the title "So-called Congenital Dislocation of the Hip,' meaning thereby to express his conviction that C D H is not truly congenital, but rather a preliminary phase, leading to a gradual upward displacement of the femoral head and thus a sort of secondary reaction, due to muscular contraction and weight bearing towards the end of the first or beginning of the second year of life, when the child begins to walk. It is only the *predisposition to dislocation* in the form of a growth disturbance of the bones affecting the entire leg as well as the corresponding half of the pelvis, and in particular the acetabulum, that is congenital Hilgenreiner however must be accredited with furnishing a more accurate description of dysplasia of the hip and therewith supplying important data contributing to early diagnosis and early treatment He, too is of the opinion that the condition is a congenital retardation of development of the entire coxal segment of the femur and of the acetabulum This condition may often be observed without any positive dislocation It is then not infrequently found in cases of unilateral dislocation and on the apparently normal side, in the form of hypoplasia of the epiphyseal osseous nucleus His conception, therefore coincides in the main with that of Lorenz However, Hilgenreiner emphasizes the fact, that the dislocation may be manifest quite early not infrequently in newborn infants in



Fig 1 *Normal morphology* of the hip joints of a newborn aged one day Note the well developed acetabular roof

the first days of life thus proving that in the strictest sense it is actually congenital For this reason he rejects the designation "so-called congenital dislocation of the hip" preferring the expression "congenital so-called dislocation" which in the final analysis is nothing but a play upon words.



Fig 2 Typical congenital *dysplasia* of both hips in a girl of three days. Family history of congenital dislocation. No other deformities in this patient. Note the obliquity of the acetabular roof

Besides this relatively common *postnatal* dislocation of the hip there is a less frequently observed prenatal dislocation fully developed at the time of birth.

Lorenz mentions these cases, distinguishing them as "genuine" congenital dislocation from the "so-called" congenital type. They are *of a completely different nature* from the ordinary pure cases. They are nearly always bilateral, combined with other congenital malformations and as a rule appear to be irreducible. Le Damany, in his treatises appearing between 1904 and 1909, contributed the clearest differentiation of the two types. He distinguished two large groups: the more common "anthropologic luxation," so called because Le Damany was of the opinion that it occurred only in human subjects, and increased in frequency with the "anthropologic level" of the race,* and a second group of rare "teratologic" dislocation caused by mechanical effects during embryonic life and combined with other severe malformations frequently incompatible with life.

In accordance with the predominating line of thought at the change of the century, he designated the anthropologic luxation as "*humanisation excessive*" and "*dégénerescence supérieure.*" These dislocations reach full development only *postnatally*, show a *predilection for the female sex*, and are *hereditary* in about 25 per cent of cases. They are only rarely combined with severe malformations, but are occasionally observed in association with minor abnormalities, such as cranial asymmetry. A characteristic feature of this type is said to be the *antetorsion* of the femoral head. Whereas in this type the dislocation is always posterior superior, in the teratologic group, the dislocation may be in any direction, according to the nature of the spatial constriction.

The distinction of teratologic from typical cases was accepted also by Hoffner, Joachimsthal and Bonder. This separation of the two groups is also especially emphasized in the author's textbook *Conservative and Operative Orthopedics* (1934). Putti distinguishes *fetal* luxation, which exists at birth in a stage of "pre-luxation," from the *embryonic* type, which corresponds to teratologic dislocation. By these terms he wishes to indicate the different time of onset of the develop-

* Dislocation of the hip occurs congenitally also in calves quite frequently (Moore, Cadiot, Cadéac).

mental disturbance. He mentions serious hereditary taint in fetal luxation but is very cautious in expressing any opinion as to the actual etiology Lance employs the same terminology, but does not consider the distinction as adamant, since on one occasion he observed a case of simple "hanche luxable" combined with other malformations He emphasizes distinctly the absence of heredity in embryonic or teratologic dislocation. M Lange has likewise differentiated the combination cases from the others, without, however, questioning the hereditary origin He distinguishes still a third group of dislocations, namely those associated with malformation of the entire inferior segment of the trunk, i e., cases of monstrous rachischisis, myelomeningocele, etc. These cases, which are usually accompanied by neurologic disturbances, led Guerin in 1841 to adopt a *neurogenic* theory, which has long since been rejected as non-applicable to typical dislocations, but which may to a certain extent be considered as valid for these exceptional cases.

We are of the opinion, that our first concern in approaching the problem, should be to classify, as simply as possible, any given case into the category to which it belongs. A purely etiologic classification would be desirable. But considering the vague conceptions of this aspect, no reliable etiological classification is possible at present For the time being therefore, we must adopt a presumptive classification, based on the different clinical manifestations We believe, to begin with that it is quite justifiable to divide C D H into *two main groups*, the *typical* C D H and the *atypical* C D H, which can be distinguished from each other by two principal features, the first, by its *postnatal appearance*, the second by its *prenatal development* and its *combination with other severe congenital anomalies* However it must be emphasized, that there may be some cases of C D H which it would be impossible to classify categorically in one group or the other Thus, in the first group there may occasionally be symptoms of subluxation present already at birth which only proves that birth, per se, constitutes no particular dividing line as regards development There are also cases of the teratologic group in which one or the other or even all

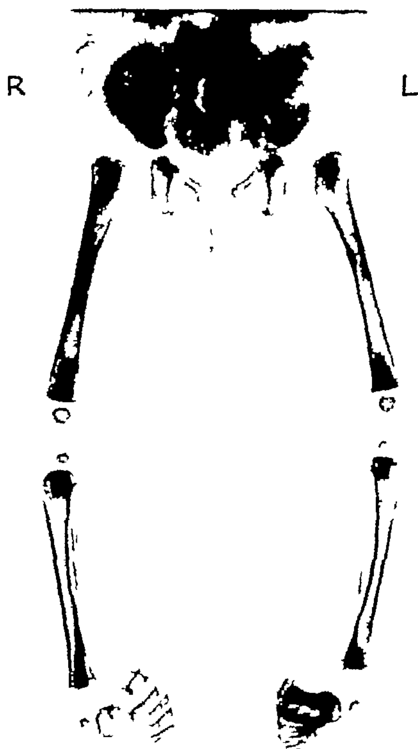


Fig 3 See legend opposite page.

associated malformations are lacking, and which can be recognized only by their prenatal development and difficulty in attempted reduction

As regards the numerical relation of the two groups to each other, we have hitherto no authentic data The few available articles on the subject by Hayashi, Matsuoka, Annovazzi and others, classify the atypical cases chiefly from the standpoint of their associated anomalies, including even the most distant malformations, such as hemangioma hare-lips, heart failure, quite unrelated to dislocation of the hip and ignoring completely the other characteristic signs of teratologic luxation as evidence of prenatal development. From the available studies it is clear, however, that the number of atypical cases is vanishingly small as compared with that of the typical dislocations. Korvin assumes that the genuine teratologic dislocations constitute about 2 per cent of all typical hip dislocations. It is worthy of note, that whereas the incidence of typical C D H in the U S A is relatively low as compared with its incidence in Europe, the frequency of the atypical cases is just the same here as abroad, which likewise demonstrates the difference of the two groups

Whereas the typical C D H usually shows a certain uniformity in its clinical manifestations, this is far from the case in the atypical group Here certain forms can be observed which differ quite markedly as regards nature and origin The types of *atypical* C D H to be encountered are

1 Cases of *arthrogryposis multiplex congenita* (Fig 3) This condition is a well defined clinical entity as described by Stern (1923) The characteristic feature consists of an universal articular *rigidity*, and usually symmetrically distributed, typical deformities, such as club hands, club feet, and contractures of the elbow, knee and hip joints. The joints themselves are not primarily involved but principally the musculature,

Fig 3 Atypical congenital dislocation of both hips by *arthrogryposis multiplex congenita* in a boy three days old, combined with club feet, club hands, and extension contractures of the elbows and knees. Family history is negative regarding the condition. Note the bilateral dislocation of the hips already fully developed at birth.

which displays a hypoplastic frequently completely spastic structure which likewise demonstrates the difference of the two groups. Such cases have been described previously under an other name (amyoplasia congenita, myodystrophia congenita) by Rocher Nové-Josserand, Magnus, Otto and others. Dislocation of the hips is a relatively common complication and always presents the type fully developed at birth. The only other dis ease with which this might be confused is spastic diplegia from cerebral palsy but in this condition, the stiffness of the limbs can be gradually overcome by passive means, and there is no actual rigidity of the joints.

2 Another type which to some extent represents the antith esis of the *foregoing*, is the hip *dislocation* associated with general congenital *flaccidity* of the joints. Since no approp riate designation has been applied, I would suggest the term *arthrochalarosis* (from the Greek arthron — joint, and chala rosis — looseness) *multiplex congenita* This term in my opin ion, sums up the leading clinical characteristics of the condi tion There may be various degrees, from simple hyperextensi-bility of the joints to complete flabbiness and dislocation of the joint The dislocation usually affects the knee or hip joints, and very rarely the shoulder elbow or finger joints. Significantly the femoral head can also be dislocated out of a well devel-oped acetabulum The femoral heads are usually displaced far upward and outward from the socket, and in contradistinction to the arthrogrypotic dislocations, are easily reducible Such cases have been described by Joachimsthal Bade, Karch Chaus-sier, Bender Hayashi and Matsuoka, Koehler and others. The condition is usually heredo-familial, and is frequently associ ated with other anomalies such as hydrocephalus (Fig 4)

3 The third type is the group with *defects and cleft for mations* of the caudal segment of the spine, which are very fre-quently combined with dislocations of the hip They include cases of spina bifida, rachischisis, partial or complete defect of the lower lumber vertebrae defect of the sacrum, not infre-quently associated with paraparesis or paralysis of the lower limbs, bladder and rectum Such cases have been described by Rendu and Verrier, Spitzy Biesalski, Feller and Sternberg Hil



Fig. 4 Congenital dislocation of both hips by congenital articular flaccidity (*arthrochalarosis multiplex congenita*) in a boy of three months. Hydrocephalus, calcanei Note the well developed acetabula and the wide distance of the femoral heads from the acetabula.

genreiner, and others We have seen three cases of this type (Fig 5) Dislocations of the hip associated with defects of certain bones of the extremities, such as the fibula, toes, etc., have also been observed (Joachimsthal Korvin) All such cases are probably best classified as the *defective* group

Dislocations of the hip in non-viable monsters have no practical significance and will, therefore, not be included in this discussion



Fig 5 See legend opposite page

We have still to consider the rare cases of C D H of specifically known etiology There are to begin with cases of *congenital traumatic* dislocation of the hip due to birth injury (obstetrical dislocation of the hip) Two cases of real dislocations of the hips caused by forcible maneuvers during delivery were reported recently by Elizalde Breech deliveries were performed in both cases, the thigh being subjected to strong traction with rotation and extreme abduction during the course of delivery In both cases there were also fractures of the femur in addition to dislocation of the hip

In this group are included also cases of dislocation of the hip in *congenital syphilis* and in *Little's disease* In congenital syphilis, dislocation is mainly due to spastic muscle rigidity and flexion-adduction contracture of the hips It remains a question, however whether the condition present in hitherto observed cases was not merely syphilitic osteochrondritis and epiphyseal detachments (C. Fraenkel, L Pick) Hip dislocation in Little's disease is due to the contracture of the adductor group and sartorius and may sometimes be of prenatal development. Most of these cases were observed in stillborn infants and doubtless had their origin during intrauterine life They are, however like the preceding cases of birth injury, special cases which have nothing whatsoever to do with C D H as such

A case which to the best of my knowledge is unique, is the case of C D H as a result of *roentgen injury* described by Korvin of the Vienna Clinic According to the anamnesis, the mother of the infant was subjected to deep roentgen therapy during the second and third months of pregnancy for arthritis of the sacro-iliac joints. The infant was delivered spontaneously at term in occipital presentation The amniotic fluid was normal in amount, the placenta was intact. Following delivery examination of the infant revealed marked microcephaly bilateral ankylosis of the elbows in slight flexion, and ulnar deviation with a defect of the ulna There was only slight inhibi-

Fig 5 Atypical congenital dislocation of both hips associated with *defect formation* of the lower spine in a girl aged two days Cleft of vertebral column with meningeal protrusion. Sister of mother had spina bifida in other sister's child had meningocele and died. A Front view B. lateral view

tion of abduction in the hip joint. The roentgenogram revealed lateral dislocation of the hip on both sides with markedly oblique acetabular vaults. The right knee-joint showed a marked posterior dislocation

Before we proceed to outline a deliberately broad and simple classification we will briefly discuss the problem of *nomenclature*

From the simple designation 'congenital dislocation of the hip" was derived that of so-called C D H because the latter was not usually to be found in newborn infants (Lorenz) When it was discovered that the pre stages of this "so-called' type were nevertheless likewise congenital, this form was designated as congenital so called' dislocation of the hip (Hilgenreiner)

We believe that the prefix of 'so-called' was in its time justifiable, in order to characterize definitely a new discovery but that it has now no place as a name in a scientific terminology, since otherwise it could be interpolated to modify any conventionally accepted professional term Nor can Putti s classification into embryonic" and fetal be considered as satisfactory since it is based not on the time of onset of the dislocation *per se* but *on the wholly vague time of onset of the primary* developmental disturbance Many of his "embryonic, or very early dislocations might from the clinical picture, roentgenograms and results of treatment emerge as typical or, in other words, fetal dislocations Le Damany's designation anthropological dislocation is on the other hand too fantastic, even if the concept of an anthropological level" could be admitted For this reason Korvin preferred to designate these cases as constitutional dislocation of the hip This term more clearly expressed the hereditary components and the merely postulated manifestations. He, too considered Le Damany s designation of "teratologic dislocations most suitable for the smaller group of cases in which the dislocation develops long before birth. With it the excessive deviation from normal and the characterization as a true malformation were well expressed We cannot subscribe to any of the above mentioned dialectic formulae but prefer to continue to speak of the congenital or

typical C D H, thus conveying an impression of the formal origin and course. We must, in addition keep in mind that besides this typical form there is also a less common *atypical* form characterized by its prenatal development and a combination with other congenital malformations.

The following classification is offered in review of the factors discussed

CLASSIFICATION OF CONGENITAL DISLOCATION OF THE HIP

I. Typical

II Atypical (teratologic)	Arthrogrypotic Arthrochalarotic Defective
III Isolated cases of specifically known etiology	Traumatic (obstetrical) Congenital syphilis Little s disease Roentgen injury

Although this book is devoted principally to the study of *typical* C D H, we will nevertheless have to discuss rather fully the atypical (teratologic) dislocations, because we are convinced that a clear distinction between these two main groups may contribute considerably toward the clarification of many hitherto vague pathogenetic and etiologic problems

Chapter IV

PATHOLOGY

THE PATHOLOGY OF C D H HAS BEEN DEMONSTRATED IN INnumerable anatomical and surgical specimens. During operation it has been possible to study in vivo not only the pathological changes but also the relation of the different components of the joints. Intensified roentgenographic studies have likewise contributed valuable information

We are indebted chiefly to the work of Hoffa Lorenz, Ludloff Horvath, Petersen, and others for an understanding of the anatomic basis of this disease Recently Putti collected nine specimens from the Istituto Rizzoli in Bologne which he has described and reproduced in his magnificent *Atlas of the Anatomy of Congenital Dislocation of the Hip* thus offering another invaluable contribution

A review of the very extensive literature on the subject reveals however much confusion in the concept of the pathologic anatomy of C D H due to an *imperfect differentiation* of the chief types of the disease namely the *typical* and *atypical* forms the properties of atypical luxation having been frequently attributed to the typical form Further confusion was caused by making pathologic anatomic studies only in *advanced* cases, in which only terminal stages could be examined C D H is not however as was formerly believed a completed condition but a pathologic process, developing from obscure initial stages, and passing through a series of phases complicated by numerous *secondary* changes Anatomic studies for the purpose of investigation of *primary* changes should therefore be made on *newborn infants* or at least on infants during the first months of life Whereas specimens of early *atypical* luxation are relatively frequently available owing to their easy detection and their frequent occurrence in association with other deformities or in non viable fetuses, anatomic specimens of *typical* luxations in newborn infants and in early

stages are very scarce. Far-sighted French investigators soon recognized these difficulties and it is told, that in the sixties of the past century, Verneuil offered, in vain prizes up to 300 francs for the demonstration of a luxation of the hip in a newborn infant with no other malformations.

For a better understanding of the peculiarities of the dislocated hip as well as the changes occurring in the course of time it seems important first of all to recall some of the important anatomic data relating to the *normal* hip joint.

According to R. Fick the *acetabulum* represents a section of 170° to 175° of a hollow sphere The roof of the acetabulum and the other two fifths of the entire surface of the acetabulum is formed by the ilium, while the base of the acetabulum, of an equal size, is formed by the ischium The pubic bone accounts

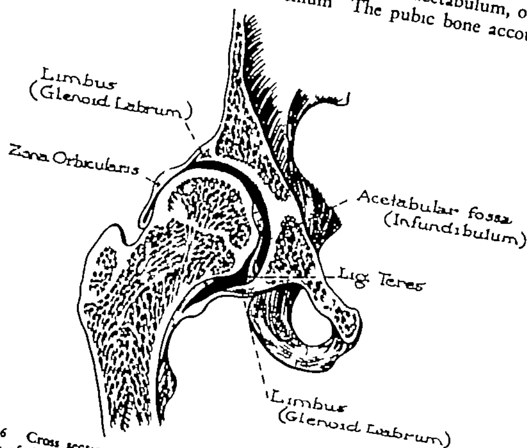


Fig 6 Cross section of a *normal* hip joint of a 12 year old boy The epiphysis of the femoral head opposite the acetabular fossa (*infundibulum*) (Redrawn from Lanz and Wachsmuth.)

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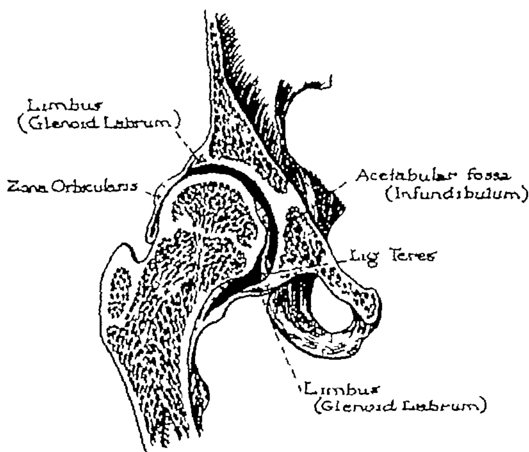


Fig 6. Cross section of a *normal* hip joint of a 12 year old boy The epiphysis of the femoral head opposite the acetabular fossa *(infundibulum)* (Redrawn from Lanz and Wachsmuth.)

for one fifth of the whole acetabular surface but provides only the anterior wall of the socket The acetabulum is directed obliquely forward and outward The cartilage-covered articular (lunate) surface has its greatest width and thickness posterior and superior at the *site of greatest strain* The rim of the acetabulum presents a wavy course, being lower in front and higher in back The acetabular fossa the infundibulum, which is not covered with cartilage, is filled by the pulvinar and lig teres (Fig 6) One peculiarity of the acetabulum is the *limbus* (glenoid labrum) which forms a fibrocartilaginous ring extending the acetabular sphere more than 180° beyond the equator and permitting a closer adjustment of the head and socket

The *femoral head* is perfectly round and forms about two thirds of a complete spherical surface.

With reference to the Y-line, it is important that the acetabular fossa (infundibulum) is located *below* the Y-line and that the center of the femoral head lies exactly opposite the *infundibulum. With the leg perpendicular, the cartilage-cov*ered upper hemisphere of the femoral head protrudes beyond the rim of the acetabulum

A. PATHOLOGY IN NEWBORN INFANTS

Autopsies of dislocations of the hip in fetuses and newborn infants which we found reported in literature, deal almost exclusively with *atypical* (teratologic) cases. Paletta's classic description (1820) concerned the cadaver of a male infant of 14 days of age, in whom the luxation was already far advanced. According to Paletta, the knees and feet of this infant were turned outward. *The lower portion of the hip joint was shut off* by the anterior capsule stretched transversely above it and the remainder of the socket was filled with a bulging fatty mass, which prevented admission of the femoral head Grawitz (*1878*) described seven specimens of newborn infants dying within a few weeks of birth all of whom presented dislocations of the hip, abdominal hernia or spina bifida, and some club foot as well and thus belonging to the teratologic group

Barth (*1885*) *reported an interesting autopsy finding* namely a right dislocation of the hip and knee in a female infant delivered

at term in occipital position, who died five weeks after birth At birth both legs were raised as in breech presentation The somewhat enlarged femoral head was displaced backward and upward from the socket thus forcing this portion of the limbus outward, whereas the anterior and inferior portion of the limbus was turned inward The socket was filled with fatty tissue. The femoral head was oval and the femoral neck short In 1895 Holzmann reported autopsy findings in fetuses and in one newborn infant, all showing dislocation of the hip combined with club foot luxation of the knee, spina bifida, abdominal hernia, etc LePage and Grosse in 1901 described a male infant who died 14 days after birth with a right dislocation of the hip extensor contractures of the lower limbs pedes adducti and cleft palate In this case there was a history of marked *deficiency of amniotic fluid*

Santon made an autopsy study of two newborn infants with C D H and bilateral club foot and found the articular changes fairly similar and far advanced in both. In one of the infants, there was only a small depression at the site of the left socket, with a diameter of only 4 to 5 mm , as compared with 12 mm. on the right side. A second socket-like depression of 7 mm in diameter had already formed in the ilium above the site of the acetabulum. The frequently reproduced picture of a newborn infant described by J Clarke, showed a strikingly small and pear-shaped luxation socket The entire half of the pelvis was narrower on the dislocated side. Also the proportion of the ossified to the cartilaginous portion differed as compared with the normal side. According to the pictures, the bony portion of the ilium had advanced above the upper rim of the luxation socket, but not on the normal side Heusner (1902) described a five months fetus with complete iliac dislocation, derived from an *extra uterine pregnancy* A second fetus of six months, likewise presented an iliac dislocation in process of development, in which the socket and capsule already showed marked changes. In 1905 Potocki described an eight and one-half month premature fetus with marked hydramnios, hydrocephalus, club foot and a fully developed dislocation of the left hip with flexure contractions.

Krukenberg described the pelvis of a newborn male infant with dislocation of the left hip The child was a hemicephalus weighing

only 1730 g., with crippled extremities Also a newborn infant pictured in the *Handbuch der orthopaedischen Chirurgie* by Lorenz and Reiner (1905-1907), with bilateral C D H, hyperextension of the left knee joint, hare-lip and hydrocephalus, belonged to the teratologic group In 1907, LeDamany reported his observations on six cases, including at least three belonging most probably to the atypical group In one embyro of three months, the left leg was in a position of outward extension and was fixed in this position by a large umbilical hernia. The hip was dislocated. In a second embyro likewise of three months, club hands were noted, and in a third case an eighth month premature, other malformations such as thyroid cyst and bronchiectases were associated with bilateral dislocation of the hip and multiple contractures.

Sippel (1921) described a dislocation of the left hip in a newborn infant, who likewise presented torticollis, asymmetry of the skull and face, as well as club foot He attributed these malformations to a postoperative unilateral fixation of the uterus and a myoma in the angle of the tube. Harrenstein contributed full detailed descriptions of two seven month fetuses with completely developed dislocation of the hips without other malformations. In both, there had been a history of trauma and hemorrhage during pregnancy Koehler describes the anatomic specimen of a new born infant with bilateral C D H genu recurvatum on the right side, genu valgum on the left side and marked talipes calcaneus. Like Sippel, he assumed that the causative factor was spatial constriction due to a retroflected and adherent uterus. Finally we must mention a contribution by Feller and Sternberg on *Anomalies of the Spine*, in which they describe and picture a premature female infant, with a wide abdominal hernia, cloaca formation meningomyclocele and exogenous scoliosis, besides bilateral dislocation of the hip The one femoral head was located posterior and inferior, the other anterior to the empty socket.

My assistant Korvin collected 39 cases of genuine teratologic C D H fully developed at the time of birth and associated with other severe malformations. To these he was able to add 10 cases from the Vienna Orthopedic Clinic In his eight sure cases, there was no mention of hereditary taint, but in six of them there was definite indication of a spatial constriction of the growing

fetus. In two cases, the pregnancy had been extra-uterine with almost no amniotic fluid

Omitting the inadequately reported and doubtful cases we thus find from a review of the literature and of our own cases a total of at least 47 cases of genuine, congenital dislocation of the hip fully developed at the time of birth Of these, at least 13 showed evidence of spatial constriction during intra-uterine development, and 35 were associated with other severe deformities of the extremities.

Reports of *typical* C D H in autopsies of newborn infants or in early cases are on the other hand extremely rare In 1905 Kirmisson described a stillborn infant, delivered at term in incomplete breech presentation with a subluxation on the left side, which was in all probability a case of typical luxation. The description of the changes observed was so clear that it deserves citation The left socket faced almost directly forward and was involved in the atrophy of the left side of the pelvis. All of its dimensions were much smaller than in the right socket. The femoral head was lodged on the posterior rim of the socket. At this level, the bourrelet (glenoid labrum) itself was flattened The whole inner and middle cavity was empty and had no connection with the femur The flattened bourrelet occupied the posterior portion of the socket. On the side the insertion of the joint capsule was normal At the os ilium, the capsule covered the bourrelet and in back of it appeared the flattened portion of the femoral head This last portion was, therefore, entirely intra articular

Le Damany studied an unselected series of autopsies of infants in the first six months of life, and was able, in four specimens to demonstrate pathologic 'pre stages of luxation He found an abnormal change in the depth of the socket, elongation of its shape into an oval, and a less clearly defined outline of its roof in the posterior, superior region. He also noted changes in the femoral head including a flattening from without inward and antetorsion There was a clearly demonstrable relation between the changes in the socket and those of the femoral head He believes these deformities were acquired because he never observed them in embyros, fetuses or newborn infants. In his opinion, the authors seeking for C D H in autopsies of new born infants fail because in the latter

the deformities have not yet developed According to LeDamany, the pathologic signs of dislocation do not develop until the 15th day of the sixth month of life, at any rate, before the end of the first year Before this time they have not yet developed, and cannot, therefore, be recognized

Besides these cases, I was able to find in the literature only one other autopsy study of a typical dislocation This was Case 2, in Putti s *Anatomy of Congenital Dislocation of the Hip* (Case 1, a fetus at term with amniotic amputation of the right half of the pelvis, inferior dislocation of the left hip absence of the internal genitals, and atresia ani evidently belonged to the *atypical* group) Putti s second case however concerning a female infant who died of bronchial pneumonia before operation could be performed shows clearly the *primary* changes of a *typical* dislocation of the left hip Examination revealed chiefly the following the left acetabulum was more sagittal and smaller but deeper than the right The upper portion of the femoral head showed a slight depression. The angle of deviation was increased (anteversion) and the angle of inclination (angle between the femoral neck and shaft) was diminished

It has been my unusual privilege to study a female infant with typical dysplasia A roentgenogram taken three days after birth revealed an abnormal flatness of the roof of the socket on both sides as shown in Fig 2 This case was recognized early, since attention had been directed into this channel by previous operation on her two sisters, three and two years of age respectively for bilateral dislocation of the hip A study of the family history revealed the fact that a paternal aunt and great aunt had been similarly afflicted This child was born normally at term but developed an attack of severe enteritis and died eight days after birth

Quite accidentally at the same time, another specimen was placed at my disposal a stillborn male infant presenting fully developed dislocation of both hips combined with club feet and club hands, as well as extensor contraction of the elbow and knee joints suggesting an arthrogrypotic type of the teratologic group These two cases are most instructive since they permit a com

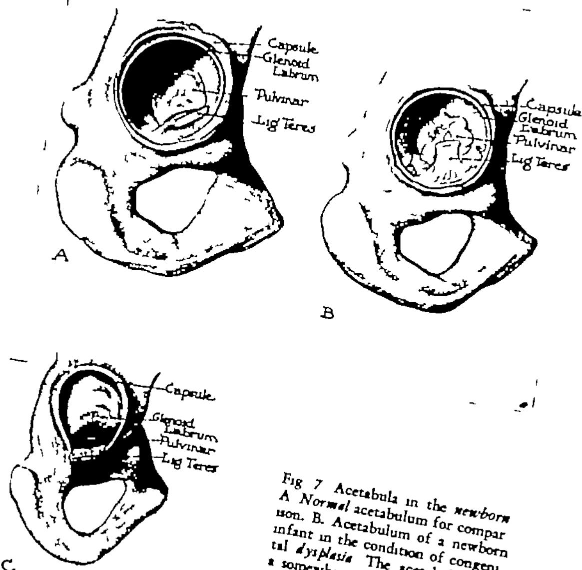


Fig 7 Acetabula in the *newborn* A *Normal* acetabulum for comparison. B. Acetabulum of a newborn infant in the condition of congenital *dysplasia* The acetabulum has a somewhat smaller circumference but corresponds to the normal acetabulum in shape and depth. C. Acetabulum of a newborn infant with *teratologic* dislocation (*arthrogryposis*) The acetabulum is considerably smaller than normal and the upper half of the acetabulum extraordinarily flat. The upper end of the capsule is markedly dilated the lig teres thickened.

parison with the normal newborn, on the one hand, and a differentiation between the characteristic pathologic features of the two main groups the typical, and the atypical C D H in newborn

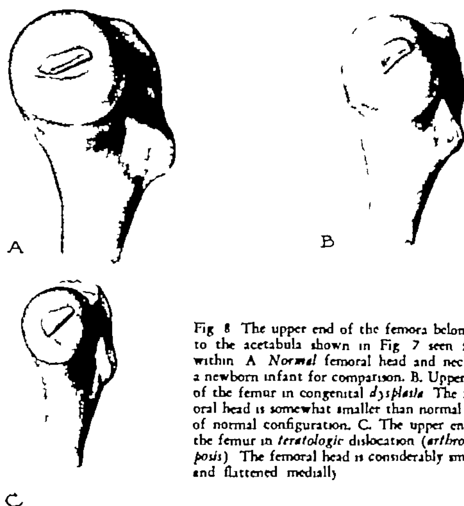


Fig 8 The upper end of the femora belonging to the acetabula shown in Fig 7 seen from within A *Normal* femoral head and neck of a newborn infant for comparison. B. Upper end of the femur in congenital *dysplasia* The femoral head is somewhat smaller than normal but of normal configuration. C. The upper end of the femur in *teratologic* dislocation (*arthrogryposis*) The femoral head is considerably smaller and flattened medially

infants, on the other hand. These changes will be described below in detail

B THE HIP JOINT IN DYSPLASIA

In the case with dysplasia the socket was slightly reduced in circumference, but corresponded in shape and depth to the normal measurements for the newborn In the teratologic case the socket was considerably smaller in circumference, only three quarters of the normal length and even more marked was the abnormal flatness of the socket. The flatness was caused by an

accumulation of cartilaginous connective tissue, not only in its base, but also in the upper half of the sockets (Figs 7A, B and C) In dysplasia, the femoral head is likewise somewhat smaller, but presents a normal configuration, whereas in the teratologic case, the femoral head was flattened medially and inclined against the upper rim of the socket (Figs 8A, B, and C) In the dysplastic case, the antetorsion angle of the femoral neck is somewhat increased as compared to normal Whereas in newborn infants it normally measures about 20 degrees, it is here about 30 degrees. The femoral neck is more perpendicular than normally In the teratologic case, the femoral neck was shortened in coxa vara and showed almost no antetorsion (Figs. 9 A, B, and C) The soft parts in dysplasia show no abnormal changes except a slight laxity of the capsule and ileofemoral ligaments, which are normally quite tough even in newborn infants.

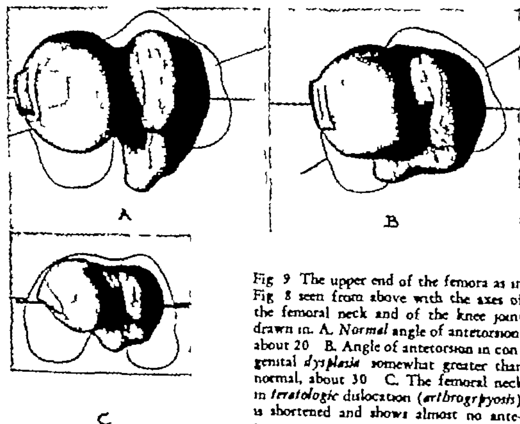


Fig 9 The upper end of the femora as in Fig 8 seen from above with the axes of the femoral neck and of the knee joint drawn in. A. *Normal* angle of antetorsion about 20 B. Angle of antetorsion in congenital *dysplasia* somewhat greater than normal, about 30 C. The femoral neck in *teratologic* dislocation (*arthrogryposis*) is shortened and shows almost no antetorsion.

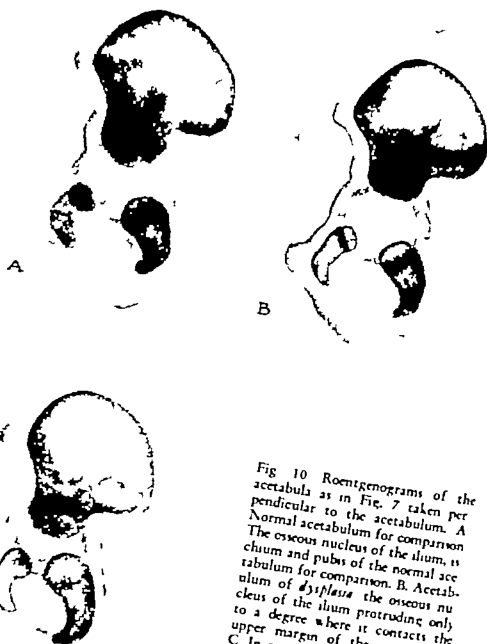


Fig 10 Roentgenograms of the acetabula as in Fig. 7 taken per pendicular to the acetabulum. A Normal acetabulum for comparison The osseous nucleus of the ilium, is chium and pubis of the normal ace tabulum for comparison. B. Acetab- ulum of *dysplasia* the osseous nu cleus of the ilium protruding only to a degree where it contacts the upper margin of the acetabulum C In contrast to dysplasia in *tera tologic* dislocation of the hip (*ar throgryposis*) the osseous nucle of the ilium, ischium and pubis are cl sely approximated toward the center

The lig teres was present. The femoral head was more than half surrounded by the cartilaginous socket as under normal conditions. In the teratologic case, the capsule was considerably thickened and dilated in its upper portion which enclosed the femoral head The lig teres was tense and thickened

To judge from these specimens, the anatomic findings in a newborn infant with dysplasia differ only insignificantly from those of the normal joint in the newborn, whereas in teratologic dislocation the changes in the joint are very pronounced, and even in the newborn infant have attained a degree seen only in far more advanced cases of typical dislocation. In other words during a few months of intrauterine life the teratologic dislocation has achieved the same development which a typical dislocation reaches only after the third or fourth year of life

Most valuable information could be gained from the roentgenological studies of the three specimens. As can be seen in the roentgenogram, taken perpendicular to the acetabulum, in the normal hip the bony nuclei of the ilium, ischium and pubis extend equally far enough central over the rim of the acetabulum to form the four quadrants of the socket. In the hip with dysplasia only the bony nucleus of the ischium extends far central enough to render possible any real ossification of the posterior inferior quadrants. The nucleus of the ileum, on the other hand has developed only far enough forward to barely contact the upper rim of the socket Thus the *posterior superior* quadrant of the socket still remains cartilaginous. Also the synchondrosis ischiopubica is wider than normal owing to underdevelopment of the nuclei of the ischium and pubis. In contrast to dysplasia, in the teratologic dislocation of the hip, not only the osseous nuclei of the ischium and os pubis but also the nucleus of the ilium had approximated each other corresponding to an already far advanced development of the osseous nuclei (Figs. 10 A, B and C)

Anterior-posterior roentgenograms of the acetabulum of a normal hip in a newborn infant showed the cartilaginous and osseous roof of the acetabulum well developed and sufficient to afford adequate support for the femoral head In dysplasia there

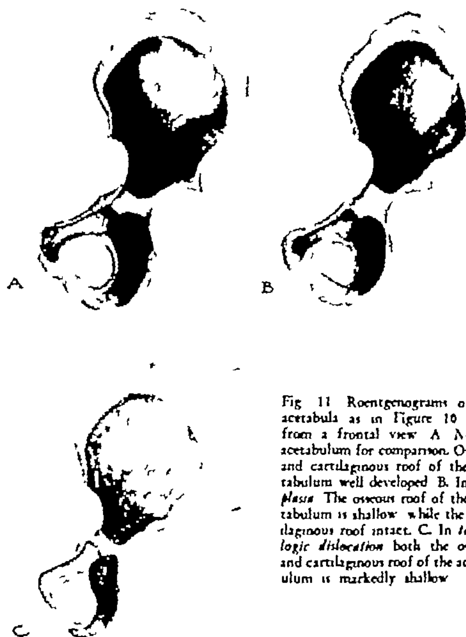


Fig 11 Roentgenograms of the acetabula as in Figure 10 taken from a frontal view A *Normal* acetabulum for comparison. Osseous and cartilaginous roof of the acetabulum well developed B. In *dysplasia* The osseous roof of the acetabulum is shallow while the cartilaginous roof intact. C. In *teratologic dislocation* both the osseous and cartilaginous roof of the acetabulum is markedly shallow

is a shallow osseous roof of the acetabulum with the tip of the cartilaginous roof in its normal place. In the teratologic dislocation both the bony and cartilaginous roof of the acetabulum are shallow (Figs. 11 A B and C)

Thus we have to deal principally with a hypoplasia of the osseous nuclei, manifested chiefly in the osseous nucleus of the acetabular root of the os ilium, whereas the cartilaginous portions of the joint seem almost intact

The incongruity between cartilaginous and osseous anlage,' and the retardation of bone development in initially normal cartilaginous parts, were convincingly demonstrated in the living subject by Faber He employed roentgenography after preliminary filling of the joint with *contrast medium*

The studies of a girl of 11 months with a roentgenologically typical picture of a shallow socket, revealed the tip of the cartilaginous roof of the socket in an exactly normal position, with normal thickness of the floor of the socket, and the femoral head

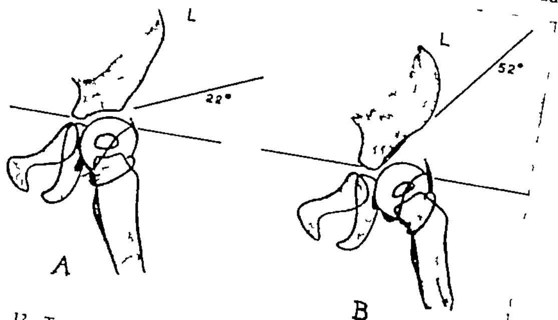


Fig 12 Tracing of roentgenograms after filling of the joint with contrast medium. A. *Normal* shape in a girl of 18 months of age. Tip of the cartilaginous roof of the acetabulum in a horizontal line drawn through the Y lines. B. *Dysplastic* hip joint in a girl of 15 months. The bony roof of the acetabulum is very steep. The tip of the cartilaginous roof of the acetabulum in normal place. This is significant for dysplasia and demonstrates the normal distribution of the cartilaginous tissue in spite of the retardation of growth of the osseous roof of the acetabulum (copied from Faber)

more than half surrounded by the cartilaginous socket, likewise in normal fashion (Figs. 12A B) Thus, contrary to our expectations, the roentgenogram of the "dysplastic hip" joint filled with contrast medium showed a completely *normal distribution* of the cartilaginous portion in spite of the considerable disturbance in the osseous condition of the joint

C. THE HIP JOINT IN THE STAGE OF PRE DISLOCATION

The characteristic features of dysplasia, as described above may also be present even in the absence of a clinically demonstrable dislocation. Hoffa Bade Codivilla and others have all reported cases which clinically gave the impression of unilateral luxation and were treated as such During the course of treatment however, and evidently favored by the increased strain on the hitherto normal side, a dislocation also of the normal side became manifest *In such cases it is frequently possible to demonstrate later an a priori disposition on the normal side.* Horvath observed that in numerous cases, the angle of inclination of the acetabular roof was much greater on the clinically normal side than on the side with manifest dislocation Furthermore, as already mentioned by Von Sandifort, in many cases the typical deformity of the congenitally dislocated proximal end of the femur *anteversion*, could be demonstrated *without* simultaneous dislocation

Scaglietti is of the opinion that dysplasia of the hip is *always bilateral* in the newborn that spontaneous healing occurs frequently *even during the fetal period* Recently Hart has presented a study of primary genetic dysplasia of the hip joint, with and without dislocation which becomes manifest only in later life. In a report of Di Prampero, based on a roentgenographic study of 200 patients with unilateral dislocation he found subluxation or dysplasia on the so-called normal side in 108 cases, subnormal hips in 41 cases, and normal hips in only 41 cases. Eighty per cent of the so-called normal hips showed pathological changes.

The condition of dysplasia therefore may persist without terminating in dislocation but some cases do progress to dislocation as demonstrated in Putti's second case (p 34) In this case examination revealed besides hypoplasia of the bony development an

already manifest inclination of the cartilaginous and bony roof of the socket, and a slightly lateral upward displacement of the femoral head The upper and posterior part of the capsule protruded markedly, the margin having two borders, the upper one formed by the capsule, and the lower one by the limbus. The lig teres was long and broader than on the right side.

In this case, therefore, we have all the features of dysplasia, but there is already a distinct tendency toward migration of the femoral head, as manifested by the upward protruding capsular wall and the upward and outward dislocation of the epiphysis of the femoral head. This case thus represents an instance of *dysplasia with tendency toward dislocation* due to yielding of the cartilaginous roof and dilatation of the capsule. The dysplasia may be uniformly present on both sides, but quite frequently one may encounter dysplasia with a tendency toward dislocation on *one* side, with only a simple dysplasia on the *other* side In one case under our observation a bilateral dysplasia in a girl of three months, the tendency toward luxation had developed on one side very rapidly in the course of three months.

At any rate, in most of these cases, the cartilaginous socket loses its formal stability Such a socket is no longer capable of resisting the increased strain of muscular activity and pressure of the femoral head on weight bearing It finally yields to the tonus and traction of the extensor muscles, which pull the femoral head from the base of the socket and tend to draw it upward, thus resulting in the upward and outward migration of the head known as *subluxation*

The fact that subluxation develops from dysplasia has been shown convincingly in a series of roentgenograms by Putti Hilgenreiner and others (Fig 13)

D THE HIP JOINT IN THE PHASE OF SUBLUXATION

In this stage the epiphysis of the femoral head may protrude *more than half from the acetabulum*, but still remains to some degree in contact with the original acetabulum. The epiphysis *rides* on the upper rim of the socket, upon which it leaves its *impression* The changes involved primarily the cartilaginous portion of the joint. There occurs a *flattening* of the cartilaginous *roof*

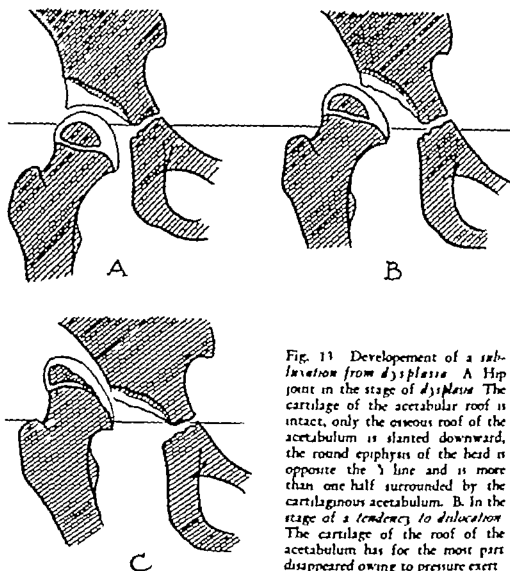


Fig. 13 Developement of a *subluxation from dysplasia* A Hip joint in the stage of *dysplasia* The cartilage of the acetabular roof is intact, only the osseous roof of the acetabulum is slanted downward, the round epiphysis of the head is opposite the Y line and is more than one half surrounded by the cartilaginous acetabulum. B. In the stage of a *tendency to dislocation* The cartilage of the roof of the acetabulum has for the most part disappeared owing to pressure exerted by the epiphysis of the femoral head thereby the epiphysis of the femoral head is displaced lateral and upward and is flattened medially C. In the stage of *subluxation* The epiphysis of the femoral head rides on the upper bony margin of the acetabulum, having assumed the shape of a "doge's cap" (redrawn from Putti)

of the socket and an elongation of the socket, which assumes a longitudinally oval or elliptical form with a depression at the site on which the femoral head rests. In effect the socket which normally has the shape of half an orange becomes oval taking on the shape of half a lemon (Calot) The articular surface is prolonged upward and extends partly over the ilium Owing to this

upward displacement, the perpendicular diameter of the socket is markedly increased Simultaneously, the femoral head exerts an enormous pressure from without inward on the *limbus*, which, at this site, is forced against the ilium and pulled up in the direction of the new position. In combination with the plate-shaped upper portion of the lunate surface, it then forms the bed for the dislocated femoral head The joint capsule is thickened and adheres above and in back to the margins of the acetabular fossa Its upper portion forms a hood for the femoral head

The changes that take place in the *femoral head* at this stage, likewise involve primarily the cartilaginous portion of the epiphysis. Owing to pressure of the epiphysis on the rim of the socket, the epiphysis is flattened from within outward Thus there occurs a mutual flattening of the socket and femoral head

It is clear that owing to this persistent strain, also the *bony* substance beneath the cartilaginous layer will be affected. The initially perpendicularly inclined bony roof of the socket becomes even more perpendicular so that frequently it passes without any break into the lateral surface of the os ilium. Once this degree of elevation is attained, the socket gives only inadequate support to the femoral head, and the latter glides farther upward along the inclined plane. Very often a furrow, the so-called sliding groove, with two sharp edges, marks the path pursued by the epiphysis after leaving the socket The normally concentrical semi-circular bony nucleus of the epiphysis of the femoral head, is forced upward and outward from the center, assuming instead of its normal shape that of a falling drop

As a result of flattening of its roof, the socket becomes more shallow Instead of a depth of 5/10 of its middle diameter, as in normal newborn infants, it finally presents a depth of only about 3/10 of its diameter The flattening of the upper portion of the socket and the associated reduction in its depth are the chief changes leading to luxation These changes do not usually develop until the period of strain, i e., at the end of the first or beginning of the second year of life, upon first attempts at walking They may however, in some instances develop earlier, and in others later, as occasionally observed in adolescents or adults.

The convincing serial pictures of Putti leave no doubt t subluxation develops from the dysplasia Also Faber has conti uted a roentgenographic demonstration of a series of four sta in which the development can be clearly followed

The process in development can be imagined somewhat follows at term the rounding of the socket is almost norr There exists at this time only a retardation in the developmeni the osseous nuclei which is most markedly manifest at the poste superior rim of the socket Owing to the deficient formal stabil resistance at the superior and posterior rim of the socket is dim ished and in response to muscular traction and strain there res a flattening at the site most exposed to pressure by the femi head *Thus as emphasized by Putti, the flattening of the soc in the stage of subluxation is not a primary, and much less a ca process, but a secondary development caused by pressure of epiphysis of the femoral head emerging from its socket*

The symptomatic triad of Putti includes the shallow soc shortly after birth, displacement after the first year of life the changes in the epiphysis of the femoral head demonstrabl a much later period

This development usually takes place toward the end of first or the beginning of the second year of life when the inf begins to walk In rare instances as the author has been able demonstrate, *it occurs much later frequently even not until a* puberty (late" dislocation)

As long as the femoral head remains within the modest lin set by the upper margin of the socket and suspension of the cap and ligamental apparatus arrest in the stage of subluxatio possible A transverse margin then forms, dividing the utili portion of the socket from the unutilized portion In this way lunate articular surface is elongated with the narrowed p uppermost and separated from the original acetabular fossa b slightly elevated arched ridge (the *bipartite acetabulum of Cal* (Fig 14) After a longer period of time the upper portion of *socket is transformed into a bony crescent shaped mound wh* may also include the iliac spine The upper portion of the cap *grows stronger with the iliofemoral ligament playing the part* an anchor chain In other cases the femoral head glides conti

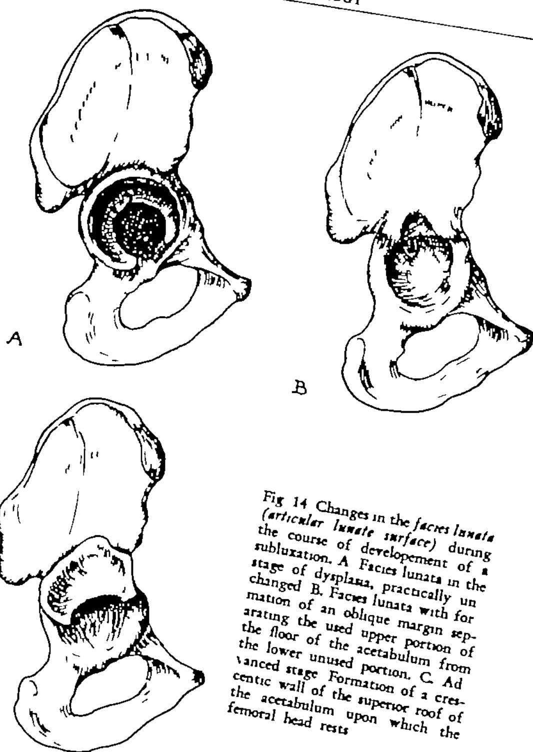


Fig 14 Changes in the *facies lunata (articular lunate surface)* during the course of developement of a subluxation. A Facies lunata in the stage of dysplasia, practically unchanged B. Facies lunata with formation of an oblique margin separating the used upper portion of the floor of the acetabulum from the lower unused portion. C. Advanced stage Formation of a crescentic wall of the superior roof of the acetabulum upon which the femoral head rests

ously onward along its oblique course, until finally all connection with the socket is lost *Subluxation, therefore represents in the*

majority of cases only one middle stage in the gradual development of complete luxation from dysplasia

Recently, Leveuf (1947) has drawn attention to certain characteristic differences between congenital subluxation and luxation citing as the essential difference between the two forms, the different position of the limbus. In a subluxation the limbus is forced upward and inward toward the iliac fossa in a luxation the limbus is forced downward and inward toward the acetabulum (Fig. 15)

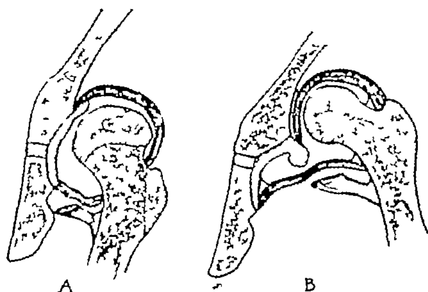


Fig 15 Condition of the *limbus (glenoid labrum)* in the stage of subluxation and luxation. A The limbus in the stage of subluxation The limbus is forced upward and lies pressed against the ilium hardly to be distinguished from the capsule B. In the stage of luxation The limbus is clearly differentiated from the capsule and turned over toward the center of the acetabulum. (From J Leveuf *J Bone & Joint Surg* 29 152 1947 Reproduced by permission of the *J Bone & Joint Surg*)

In his opinion subluxation and luxation represent "different malformations. Both malformations originate at a stage of embryonic development, and from the initial stage of subluxation and luxation develop individually toward essentially different anatomical conditions. He cites Gourdon who in 1906 stated that "subluxation is a relatively stable condition which never tends to develop into a luxation "

This conception of Leveuf which appears also to have been shared by other French writers, is in direct contrast to the clinical

experiences of the majority of orthopedic surgeons (Hoffa, Lorenz, Putti, Waldenström, Albee, Gill, Fresberg, Wiberg, Hart and others) It cannot be denied that the femoral head in its upward migration may become permanently fixed in its new position of subluxation, presenting a clinically and roentgenologically clearly defined entity with distinct anatomical features The acetabulum in subluxation may present a scooped out appearance Valgus deformity and anteversion of the femoral neck are very common in subluxations and rare in luxations.



Fig 16 Transition of a subluxation into a luxation. This girl had received no treatment Roentgenogram at the age of three years in the stage of subluxation on the left side.
Fig 17 The same case as in Fig 16 two years later in the stage of complete luxation on the same side

Also the difference between subluxation and luxatior the relation of the limbus, is a fact to which Ludloff (19 drew attention long ago. All of these changes occur howe only in *older children* and are not *primary* as assumed by Lev but *secondary* manifestations *due to the formative influence w induces the different position* Most observers agree that subl tion is a transitional stage experienced by all cases on their to luxation or as Waldenström expresses it By subluxatio c congenita we understand a condition which may be best cha terized by the words on the way to luxation If like Lev he has not hitherto observed a transition of subluxation to luxa this is because this transition as a rule takes place so early, a so rapidly accomplished that it easily escapes notice That cases occur is shown in Fig 16 and 17 Morphologically, more there is no difference between Leveuf s primary subluxation the residual subluxation which we encounter so frequently lowing closed or open reduction owing to deficient developm of the roof of the acetabulum, and which certainly canno



Fig 18 Roentgenogram of a girl 5 years of age shows coincidence of luxation on the right side and complete dislocation on the left side

regarded as a "primary" change. The most convincing evidence, however, of the relationship between subluxation and luxation is offered by the fact that subluxation and luxation may coexist in the same individual (Francillon, Hart and others) (Fig 18) As Hart states, 'Subluxation as well as dislocation, is a consequence of the primary genetic dysplasia or incompetent acetabulum'

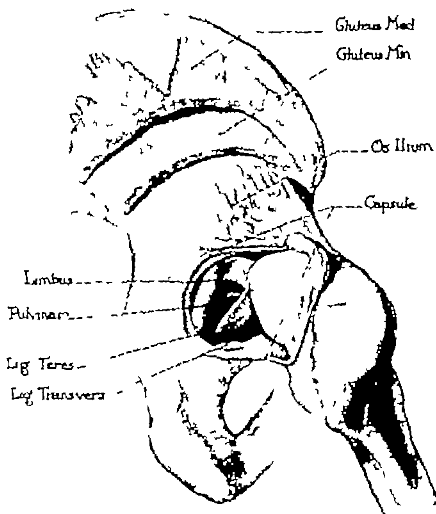


Fig 19 Specimen of a complete dislocation of the right hip in a girl of four years. The acetabulum is markedly flattened, the limbus turned inward The acetabular fossa filled with the racemose fatty tissue of the pulvinar The lig teres is thickened and broadened. The femoral head is reduced in size and shows a medio-posterior flattening

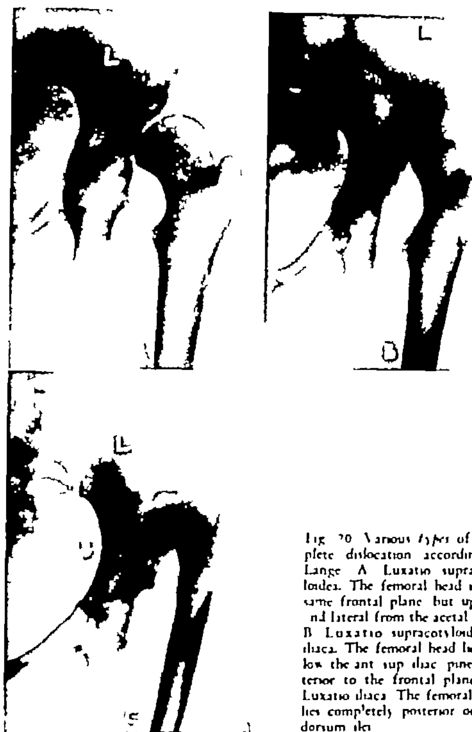


Fig 20 Various *types* of complete dislocation according to Lange A Luxatio supracotyloidea. The femoral head in the same frontal plane but upward and lateral from the acetabulum B Luxatio supracotyloidea et iliaca. The femoral head lies below the ant sup iliac spine posterior to the frontal plane C. Luxatio iliaca The femoral head lies completely posterior on the dorsum ilei

E. THE HIP JOINT IN THE STAGE OF LUXATION

In this stage the femoral head has moved *completely over the rim* of the acetabulum and has lost its contact with the original acetabulum (Fig 19) To begin with, it must be emphasized that even in this advanced stage the femoral head may show all possible transitional positions between the one extreme, above the upper rim of the socket, to the other, in back of the ilium We are, therefore, confronted with an extremely manifold variety of anatomic and clinical pictures. Phelps (1881) first and later Koelliker (1895) drew attention to this fact.

In this comprehensive series of individual forms regarding position, Lange distinguished three chief types (Fig 20)

1 Luxatio supracotyloidea.
2 Luxatio supracotyloida et iliaca
3 Luxatio iliaca

The first of these types is characterized by the fact that the femoral head lies in the same vertical plane as under normal conditions, or in front of it but always at the same time higher and lateral from the normal position This type corresponds to the 'anterior' congenital dislocation and is frequently combined with anteversion of the femoral neck in which the femoral head appears prominent in the anterior aspect of the pelvis In the second type the femoral head lies below the anterior superior iliac spine and at the same time somewhat posterior to the frontal plane of the iliac surface. In the iliac type the femoral head lies completely posterior on the dorsum ilii

Hoffa distinguished four types

1 Direct upward luxation the femoral head lies forward directly beneath the anterior superior iliac spine.
2 Upward and outward luxation, also here the femoral head is palpable only in front, but more outward from the spine (Schede's luxatio subspinalis)
3 Luxation directly outward from the spine, the head is here usually farther up than in the first two types.
4 Posterior superior luxation, the head lies in back of the ilium.

These types could be still further diversified but for practical purposes, it suffices to recognize only three stages of the development In the interest of simplicity we are, therefore, usually satisfied to speak of an *anterior*, a *lateral* and a *posterior* luxation taking for granted of course that each of these is simultaneously a *superior* luxation Anterior luxation is probably most often a subluxation, i e the femoral head is in process of mounting the posterior superior rim of the socket, but its inferior pole is still perpendicular to the socket McCarrell and Crego made an attempt to emphasize *anterior* luxation as a *primary* anterior type, worthy *of special distinction in the various types of luxation* Naturally the individual types cannot be clearly distinguished and moreover there are usually transitions from subluxation to anterior luxation *as well as from anterior to posterior These transitions* occur so gradually and insidiously that they might easily escape detection

If the femoral head has completely departed from the socket then the hip joint is exposed to secondary changes due to mechanical factors, retrogressions, growth disturbances and processes of adaptation *The degree of the symptoms depends not only upon* the age of the patient but also upon the time and extent of the migration of the femoral head

In the following pages we will describe the pathologic changes of complete dislocation in all its aspects.

1 The Dislocation Socket

In the stage of dislocation the above mentioned deviations in the acetabulum are accompanied by changes due chiefly to hyperplastic changes in the socket which reduce its size This transformation is brought to pass first of all by changes in the *limbus*, and later in the rim of the socket as first demonstrated by Ludloff As the femoral head glides upward and slips out of the elastic loop of the limbus, owing to the general increased elasticity of the limbus, there occurs a *turn of the limbus toward the center of the socket* in the posterior superior quadrants, so that its free margin is directed toward the acetabular fossa. The limbus then forms a transverse crescent back of the inferior margin of the upper portion of the acetabular fossa rising like a cupola The limbus

thus exerts a diminishing effect on the acetabulum not only by its displacement into the socket, but also by a gradual pulling of the anterior and posterior margins of the acetabulum into the acetabular cavity

The surrounding margin of the limbus may persist for a long time and can be palpated as a ridge, it may during this stage form an obstacle to the proper concentric adjustment of the femoral head in reduction Putti, however, believes that the limbus plays a part in the mechanism of reduction only after the second or even third year of life. *The more rapidly, moreover, that this transition from subluxation to complete luxation takes place, the sooner it becomes possible for the limbus to turn inward whereas in a more prolonged persistence of the stage of subluxation, the limbus remains inclining upward and becomes adherent to the ilium* Later, the limbus undergoes a more or less complete atrophy, which occasionally also leads to ossifications In this case, the rim of the socket presents a rounded wall, with no suggestion of a limbus, whereas in its internal inferior quadrant, i e. above the acetabular notch, it may long remain intact. The inward torsion of the limbus is not, therefore, as assumed by Leveuf, a primary symptom definitely indicating luxation, but an associated symptom of a different stage of the same underlying process, which can be explained by the changed mechanical conditions

A further flattening of the socket is also abetted by the *pulvinar*, a pad of fat and connective tissue lining the base of the socket around the lig teres In the stage of luxation this pad becomes so hypertrophied that it includes also a portion of the lunate articular surface In addition, the *lig teres* usually increases in thickness up to the third year of life. However, it would be a mistake to imagine that the entire capsular sac is filled with proliferated tissue from the base of the socket Rather, there remains at first a cavity filled with synovial fluid as very clearly demonstrated in Faber s injection pictures This proliferation, in the socket may however proceed to a complete leveling In such cases, the bony socket has the appearance of being filled with a congealed cartilaginous mass There is almost no differentiation of the cartilaginous layers of the socket (hyalin- or fibrocartilage), and the superimposed connective tissue layer is barely suggested

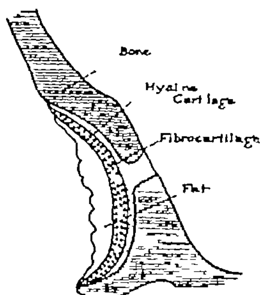


Fig 21 Layers of a dislocation socket The limit between the hyaline cartilaginous layer and the superimposed fibrocartilaginous tissue layer is barely suggested (according to Deutschlaender)

(Fig 21) The posterior superior rim of the socket is usually flatter than the rest of the acetabular margin Thus the floor of the socket with the simultaneous inhibition of growth in length and width grows thicker Hoffa and Lorenz in their numerous open reductions were greatly impressed with this thickness of the floor of the socket The hypertrophy involved all of the constituent tissues of the acetabulum fatty and connective tissue as well as cartilage and bone *The hypertrophy of the cartilage* was the most marked Lorenz explains this thickening as being due to a retarded consumption of cartilaginous substance corresponding to the general retardation of growth in the hip region Ludloff on the other hand considers it as a secondary filling hypertrophy due to relief of strain on the base of the socket

In contradistinction to the more or less complete leveling of the acetabular cavity by connective tissue hyperplasia an extraordinarily long persistence of the original depth of the socket has been observed in some cases (Cruveilhier Dupuytren Luren Mikulicz Fournier and others) The shorter the time that the upper portion of the socket is exposed to the levelling effect of the femoral head in other words the more rapidly the socket is

liberated from abnormal pressure, the sooner will some continuation of development ensue. The rim of the socket, when relieved from the pressure of the femoral head, will, therefore, continue to grow out to a certain degree This takes place usually in the sixth or seventh year of life (II dentition period), when the epiphyseal nuclei are in the most lively stage of ossification. It is easy to understand that the bone centers of the socket are particularly affected by this growth impulse, thus contributing to its formation This innate capacity for continued development of the acetabulum is of determining significance in the closed treatment of C D H, the results of which are dependent upon the development of the bony structure of the socket

In adolescence, the bony covering of the acetabulum is considerably attenuated. Furthermore, it loses its cartilaginous character and becomes more like periosteum At a more advanced age, the acetabulum undergoes progressive involution, until finally it is transformed into a shallow depression triangular in shape, and with an amorphous surface, with practically no resemblance to its former shape (Fig 22)

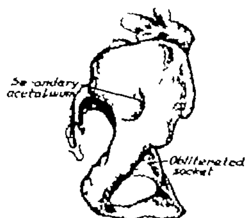


Fig. 22 Old *dislocation socket* The original acetabulum is small, flat and of triangular shape Above and posterior to the deserted acetabulum is a deep impression corresponding to the new position of the head

2 The Secondary Acetabulum

If the femoral head has emerged out of the old socket, a neoarthrosis usually develops facing its new location (Figs. 23, and 24) As a rule, that site on the wall of the ilium against which the femoral head is inclined causes at first only one or more faint impressions, in the vicinity of which the capsule adheres to the periosteum Such neoarthroses have been observed in children (by



Fig 23 Dislocation skeleton of a woman 28 years of age. The femoral head lies in a *secondary acetabulum* above the old obliterated socket The new acetabulum auricular in shape the femoral head mushroom shaped.

Fig 24 Roentgenogram of the dislocation skeleton showed in Fig. 3

Elliott in a boy of seven years and by Wrolik in a boy of twelve years) but are generally rare at this age On the contrary neoarthroses in adults are observed more frequently the older the individual In such cases, there must in all events have taken place a preliminary perforation of the capsule Of special interest are the roof formations springing from the periosteal proliferations which frequently afford considerable support to the femoral head in its new position and occasionally lead to a complete enclosure of the femoral head (Fig 25) As a rule however the processes directed toward substitution of the socket are only of slight degree or even just barely suggested

Farkas emphasizes the difference between typical and teratologic cases as regards the secondary acetabulum If the dislocation occurs during *embryonic* life there will be a deep secondary socket with well developed upper margins, as a result of the continuous pressure of the head against the wall of the ilium If the dislocation occurs after birth the secondary socket will be broad and shallow

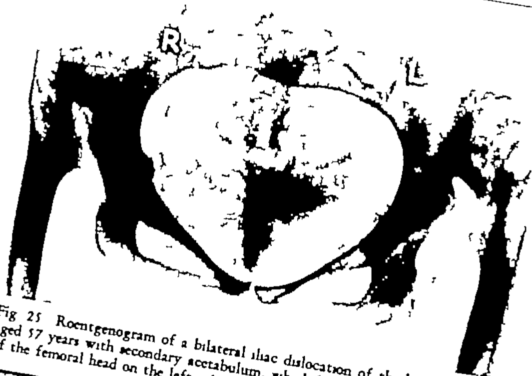


Fig 25 Roentgenogram of a bilateral iliac dislocation of the hip in a woman aged 57 years with secondary acetabulum, which had led to complete enclosure of the femoral head on the left side. Good stability but limitation of motion.

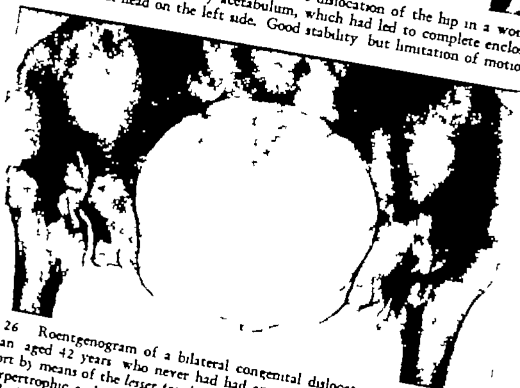


Fig 26 Roentgenogram of a bilateral congenital dislocation of the hip in a woman aged 42 years who never had had any treatment Spontaneous pelvic support by means of the *lesser trochanter* had developed. Both lesser trochanters are hypertrophic and articulate at the site of the acetabula. Clinically the patient had no complaints.



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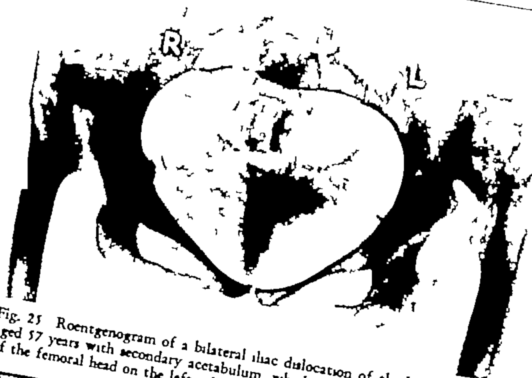


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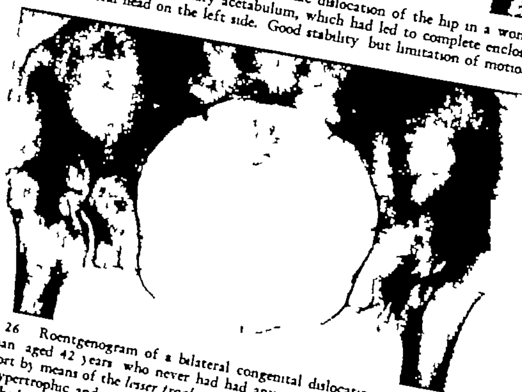


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and without any well-formed upper margin owing to friction of the gliding femoral head on the ilium This difference, however, according to our observations, is only present in young children later on, the differences becomes less manifest, so that even in typical dislocations the secondary socket will be deeper and may have a well developed upper rim

Of special interest is a case of our observation in which the *lesser trochanter* faced the acetabulum, and in which an articulation was formed between the original socket and the lesser trochanter, with excellent pelvic support (Fig 26) Such cases have been *observed also by Scherb Putti and others.*

Genuine neoarthroses will later on frequently become the site of pathologic changes resembling those of degenerative osteoarthritis

3 The Femoral Head

The changes which occur in the femoral head during the stage of luxation are, like those in the acetabulum of a regressive nature, and depend partly on changed mechanical and functional conditions The most striking change in the femoral head is its *reduction in size* It is diminished in all its dimensions This diminution is a partial symptom of the general atrophy of the dislocated half of the pelvis and increases with age At certain periods, however, and most particularly during puberty the femoral head may become *enlarged due to an increased growth tendency* which still farther accentuates the disproportion between the femoral head and the socket the latter being retarded in its growth.

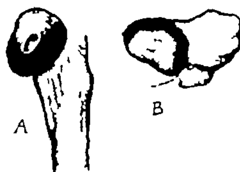


Fig 27 Deformity of the femoral head in an untreated dislocation. A. View from within. B. View from above *Medio-posterior flattening* of the dislocated femoral head (From Lorenz and Reiner)

Besides the reduction in size, still other changes occur in the femoral head, one of which is especially typical, this is the *medio-posterior flattening of the femoral head* Viewed from within, the internal apex of the head appears flattened and broadened Looking at the femoral head from above, we see that the uniform inward and backward bulging of the head has disappeared, giving place to an almost extended curve (Fig 27) Below the somewhat rounded apex is the fovea Frequently, a groove may be seen in the head leading upward to the fovea the trail of the lig teres long since destroyed This flattening of the head is secondary like that of the acetabulum, but constitutes nevertheless a characteristic feature of the congenital dislocated joint.

The deformities of the femoral head described above, have not only theoretical significance, but may, if they attain any marked degree, have a distinctly unfavorable effect on prognosis.

In later life, the flattening may become more pronounced, according to the position of the femoral head in its new location, and to pressure strain forcing it against its new bed Even the entire head may be involved in this flattening, until it resembles a railway



Fig 28 Deformities of the head at more advanced age A Buffer head. B. The femoral head is almost completely absorbed leaving only a small irregular stump

shock absorber (Fig 28A) The margins of this structure are turned markedly inward, producing a mushroom shape Other *shapes have also been described The femoral head may either be* resorbed alone or together with the femoral neck leaving then only a small irregular stump perched on the inner aspect of the trochanter (Fig 28B)

In general, it may be noted that the development of the femoral head and that of the socket run a fairly parallel course, i.e a well shaped femoral head is associated with a well shaped socket. This is not always so, however, and as mentioned above, at the time of puberty one may encounter a strongly developed femoral head with a poorly developed socket

4 The Femoral Neck

The proportions of the femoral neck may be practically normal in dislocation but usually there are more or less marked deviations.

Frequently there is an increased angle of the femoral neck *coxa valga,* which has been variously interpreted (Drehmen,

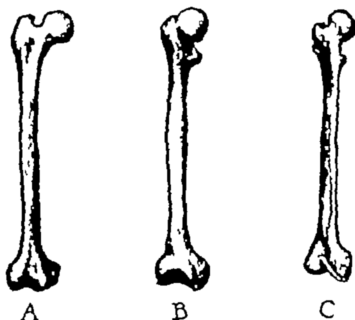


Fig 9 Deformities of the femoral neck A Normal femur B Femur with marked anteversion. C. Femur with marked retrotorsion (according to Lange)

Springer, Preiser, Putti) Preiser describes congenital coxa valga as a preliminary stage of C D H, while Putti refuses to ascribe any significance to it Usually, a diminished inclination of the femoral neck i e, *coxa vara* is mentioned (Vrolik, Gurlt, Malgaigne and others) The flattening of the femoral neck angle may be so marked, that it is changed from the normal of 130° to a right angle. Usually one has to deal with a downward direction of the epiphysis, as well as with an abnormal shortness of the femoral neck. Frequently this is a result of too early weight bearing following reduction when the still soft epiphyseal line between the head and the neck of the femur gives way There are also cases of unilateral dislocation, with pronounced coxa vara on the non-luxated side (Albert, Alsberg, Rager) interpreted as deformities due to strain

Of much greater importance than the variations in the angle of the femoral neck, is the forward torsion of the axis of the femoral neck in relation to the transverse axis of the knee joint which has been designated as *anteversion* (Fig 29A and B) This angle is even normally subject to certain variations. Le Damany found no anteversion in a fetus of four months but from that time to the time of birth noted 30-60 degrees of anteversion In new born infants the anteversion averages 15 to 20 degrees, but an involution follows so that in the second year of life the average anteversion is 35 degrees. In adults, it is never more than 10 to 12 degrees Thus the normal human femur, which originally shows no signs of torsion, undergoes some degree of torsion before birth and detorsion after birth. The torsion occurs in the proximal epiphyseal line. Not too infrequently one may even observe in adults a *retrotorsion* in the absence of any abnormality of the hip joint (Fig 29C) Attempts have been made to explain these conditions of torsion in the femoral neck mechanically by torsion displacements involving the thigh in the very earliest period of embyronic life.

Endless time and trouble were also expended thereafter in attempting to measure the angle of anteversion without any significant addition to our knowledge. Thus Kingsley and Olmsted and Knight, in a study of 630 adult femurs, found a normal anteversion of 5° to 10° in 25 percent of all adult femurs. These

authors believe that any angle of anteversion in the adult femur exceeding 10° approaches the abnormal, and that an angle of more than 15° is definitely pathological It should also be considered that the female type shows slightly more pronounced anteversion than the male type. This study supports the claim that the infant femur normally presents a high degree of anteversion (average 24 4°) and that during childhood and adolescence, this gradually recedes to that seen in the adult A reverse angle or angle of retroversion *is a frequent finding and its incidence in the adult is nearly as* common as the finding of an abnormal degree of anteversion.

Actually, in dislocated hip joints, the anteversion remains unchanged after birth or may even increase. Lange and Pitzen attribute this to the fact that in the absence of normal strain and normal motor excursions, the process of involution does not take place In older cases of C D H anteversion may reach such a marked degree, that the femoral head is turned directly forward the axis

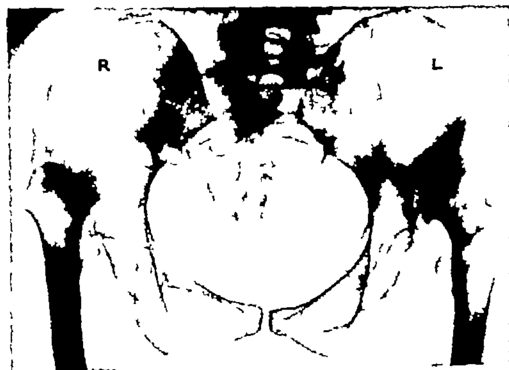


Fig 30 Bilateral congenital dislocation of the hip in a man of 33 years. The patient had never been treated. Luxatio supracotyloidea on the left side and luxatio iliaca on the right side. Note deformity of the head and the anteversion on the left side and the well shaped head and neck on the right side

of the femoral neck forming an angle of 90° with the transverse axis of the knee joint Such marked anteversions, however, found only in subluxation, lateral luxations and following unsuccessful attempts at treatment, are in our opinion of a *secondary* nature as a result of the permanent pressure of the femoral head against the hard, posterior wall of the acetabulum It is, at any rate, a striking fact, that *in posterior dislocation, the femoral head is usually well shaped and not twisted at all* (Fig 30)

The anteversion of the femoral neck is often associated with still another type of torsion, namely a forward torsion of the proximal metaphysis of the thigh, thus still further increasing the sagittal position of the femoral neck and the impression of anteversion Von Mikulicz (1896) was the first to draw attention to this type of torsion Friedlaender relegated the spiral torsion of the diaphysis of the femur to the period of intrauterine growth whereas Lange attributed it to the peculiar distribution of muscular pull in the post-fetal period

5 The Dislocation Pelvis

Even in early dislocation one is impressed by the general hypoplasia of all components of the pelvis on the side of the luxation A partial symptom of this retarded growth is the persistence of the epiphyseal cartilage between the ascending ischium and descending pubis, which may continue to puberty It is clear that hip dislocations of long duration, whether uni- or bilateral may for several reasons react upon the shape of the pelvis They displace the site of connection of the hip bone with the femur change the pressure conditions in the pelvis, shorten the extremities and bring them into an abnormal position In this way the support of the pelvis by the limbs is changed, as well as the mechanism of standing and walking

The dislocation pelvis in *bilateral* dislocation of the hip is usually described as a transverse spanned pelvis with a markedly increased transverse diameter (Fig 31) This has been attributed to the abolition of pressure against the acetabulum At the pelvic orifice this increase in the transverse diameter may attain 15 mm or more The pelvic orifice (superior apertura) thus assumes a transverse oval shape which is still further em-

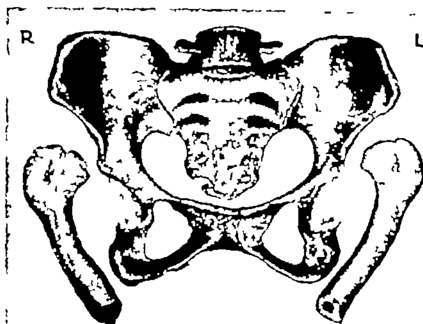


Fig 31 *Symmetrical* bilateral dislocation pelvis. Oblique high ilii with deep iliac fossae The ischii directed markedly outward and forward. Arcus pubis low and very broad (from Breus and Kolisko)

phasized because the sagittal diameter (conjugata vera) is not infrequently slightly shortened At the pelvic outlet the transverse diameter is even more markedly increased The cause of this lies in the eversion of the ischial protuberance, which also causes an extraordinary flattening of the pubic arch and increases the angle of the pubic bones. Thus the latter and the ischii frame the obturator foramen above and below, almost horizontally (Vrolik) Owing to the increased lordosis, the promontory protrudes considerably so that the sacrum appears markedly concave

The iliac fossae are more perpendicular and approximate a vertical position Thus the transverse diameter of the greater pelvis is markedly diminished The perpendicular direction of the iliac fossae leads to a superimposition of the superior on the inferior spine in the same vertical plane Cruveilhier Hyrtl Kehrer and others claim that the pressure exerted by the dislocated femoral head on the external surface of the pelvis is responsible for the erection of the iliac blades whereas on the other hand von Vrolik and Lorenz and others consider the forward and inward traction

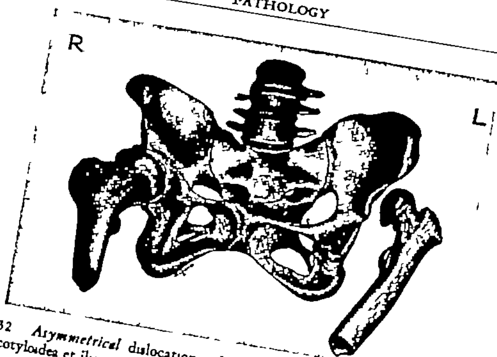


Fig 32 *Asymmetrical* dislocation pelvis of a woman of 38 years Luxatio supracotyloidea et iliaca of the left hip with secondary acetabulum. Subluxation of the right hip with broadening of the acetabular roof Pelvic inlet heart shaped. Symphysis displaced toward the right and slightly beak shaped Arcus pubis very low and wide with its left limb elongated. Pelvic outlet markedly asymmetrical the right half broadened, the right ischium displaced outward and forward (from Breus and Kolisko)

of the iliac muscles on the crests of the ilii is to blame. If we add the even more marked frontal depression of the pelvis caused by the posterior displacement of the femoral head, especially in iliac luxation, we then have before us all the significant changes of the luxation pelvis. The latter is, therefore, a simple smooth pelvis, its so called guiding line is accordingly shortened and less curved. From an obstetric point of view, the pelvis in bilateral dislocation of the hips constitutes no complication but must rather be considered as a favorable obstetric pelvis

In *unilateral* luxation the two halves of the pelvis are dissimilar, and the pelvis is therefore asymmetrical (Fig 32) The side of the luxation is always lower but also more spacious in all pelvic planes. According to Vrolik under these conditions the sagittal plane through the middle of the promontorium divides the pelvis into two halves of unequal size, of which that on the side of the luxation is the broadest This sagittal plane no longer reaches the symphysis but the horizontal portion of the pubic bone on

the normal side The pelvis is, to put it briefly obliquely con stricted on the normal side, and furthermore displaced forward toward the side of the luxation Thus on the side of the luxation, the lesser pelvis is dilated, whereas the greater pelvis, owing to the vertical position of the ilium, is constricted Litzmann explains the asymmetrical constriction in unilateral dislocation by the fact that the pelvis is compressed on the normal side by pressure of the femoral head in the direction of its oblique diameter The pelvis asymmetry in unilateral luxation causes difficulty only rarely and only in combination with other changes.

Rader was able to collect a series of 26 deliveries in women with dislocations Of these 17 were unilateral and nine bilateral. In the former, with the exception of a single case in which forceps were used delivery was normal, whereas in the nine cases of bilateral dislocation three required artificial aid Vertex deliveries were made in all 26 cases.

6 Capsule and Ligaments

Normally, the capsule forms a sac which completely veils the shape of the joint bodies and permits no differentiation In the stage of subluxation and luxation, the upper portion of the capsule is stretched over the femoral head, clearly revealing its contours (Fig 33) The farther the femoral head recedes from the socket the more the capsule is drawn out into a tube which at the level of the upper rim of the socket, shows a narrowing by the so-called *isthmus* This narrowing is caused partly by stretching of the capsular sac, but principally by pressure on the limbus In cases of marked elevation of the femoral head also the tendon of the ilio-psoas muscle contributes to the constriction, because it en circles the anterior wall of the capsule, as in a loop, and presses it against the rim of the socket (Fig 34) In some cases, the capsule is subjected to an "hourglass constriction of the isthmus which may present a considerable obstacle to reduction Such a constric tion will only be found however in children of more than three years of age, and even then only in cases of very marked displacement

The upper portion of the capsule forms the well known *hood* of the femoral head which it closely covers This is originally that

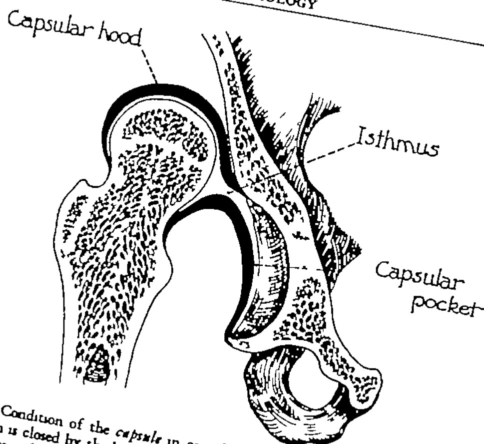


Fig 33 Condition of the *capsule* in complete dislocation. The mouth of the acetabulum is closed by the lower leaf of the capsule, which is tightly stretched upward across the acetabulum.

portion of the capsule wall which lies behind the superior ilio-femoral ligament the femoral head advancing from below stretches the capsular wall and determines its shape.

The capsular wall becomes stronger with advancing elevation In older individuals, the wall of the capsule may attain a thickness of 1 cm or more. Hypertrophy can be attributed to the supporting function assumed by the capsule after emergence of the femoral head from the socket. Although it is unable to resist for any length of time the extending traction of the body weight, it responds initially to the intensive functional stimulus with a considerable tissue hypertrophy The articular ligaments are also markedly involved in this process. Not infrequently there occurs a fusion of the capsular hood with the adjoining periosteum of the ilium, this usually does not develop until the sixth to eighth year, but may be so considerable as to provide a marked obstacle to lowering of the femoral head (Fig 35A)

The lower portion of the capsule springing from the anterior inferior rim of the socket is stretched tent-shaped over the socket and forms the so-called capsular pocket, which holds, not only the pulvinar proliferating in the socket, but also the lig teres.

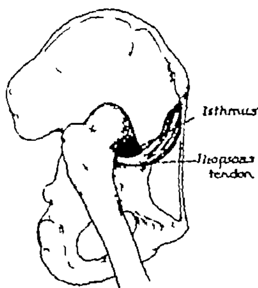


Fig 34 Constriction of the isthmus by a loop of the tendon of the ilio-psoas.

Adhesions of the capsular pocket to the floor of the acetabulum are rare when they do develop the inferior joint space may be reduced to a small canal, or may be completely obliterated (Fig 35B)

Also at the femoral insertion of the capsule a *pericapital* adhesion may develop owing to constant pressure, as first suggested by Putti, so that the capsule is inserted in the epiphysis instead of in the femoral neck (Fig 35C) This is important because in reduction it may hinder entrance of the head into the socket

Among the significant reinforcing ligaments of the capsule may be mentioned the *superior iliofemoral ligament*, which inhibits adduction and inward rotation of the extended limb, as well as outward rotation of the flexed limb and also the *anterior iliofemoral ligament* which inhibits chiefly over-extension The ischiofemoral and pubofemoral ligaments are relatively weaker and less significant. Also the zona orbicularis, which encircles the capsular sac as a reinforcing band has indirect significance as a reinforcing ligament Gocht has seen cases in older children in which the

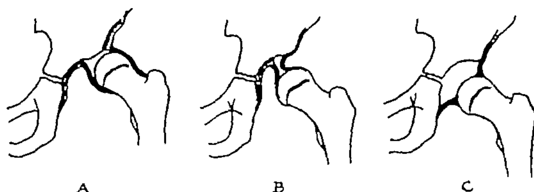


Fig 35 Capsular adhesions. A. Adhesion of the capsular hood to the os ilium. B. Adhesion of the capsular sac to the floor of the acetabulum. C. Pericapital capsular adhesion. The capsule is inserted on the epiphysis instead of on the femoral neck (redrawn from Putti)

superior iliofemoral ligament appeared to be considerably strengthened by it, whereas the anterior iliofemoral ligament was markedly atrophied. The difference in the condition of the two ligaments might be explained by the fact that the superior ligament, owing to its horizontal course is stretched on even slight elevation, therefore functioning like a band, whereas the anterior ligament which passes downward and outward at an angle of 45 degrees, is immediately relaxed and becomes atrophied from lack of use.

The *lig teres* is peculiar in that it disappears relatively very early According to an interesting tabular presentation of 100 operated cases by Lorenz, this ligament is missing in one half of the cases at three years of age In the fourth and fifth years of life, the ligament is practically constantly absent, and from the sixth year on, its presence is an exception The ligament no doubt degenerates owing to the functions relegated to it by dislocation of the femoral head and straining its capacity Together with the rest of the ligamental apparatus it bears the body weight, becoming hyperextended and attenuated. It may even be worn through mechanically by friction since it is stretched like a cord over the upper posterior rim of the socket, leaving traces of its pressure on the medial and medioposterior sides of the femoral head

In those rare cases in older persons, in which the lig teres persists it is found hypertrophied in the shape of a plate one to one and one-half cm in width It rises out of the socket passing over

the posterior superior rim of the latter along the flattened surface of the femoral head to the upper margin of the fovea Since in bilateral cases, the dislocation often differs on the two sides, the condition of the lig teres will likewise differ

7 Muscles

The displacement of the femur in relation to the pelvis necessarily changes the topical relation of the points of insertion of all the muscles extending from the pelvis to the thigh. This displacement of the sites of insertion affects the direction and degree of tension of the musculature Every lasting approximation of the insertion leads to nutritive *shortening* Every persistent extension results in an accommodative *lengthening*

The muscles extending from the pelvis to the thigh may be divided into two groups

1 The short muscles of the pelvi trochanteric group which run a more or less horizontal course.
2 The group of long *pelvi femoral* and *pelvi crural* muscles, which run a vertical course.

The first group includes primarily the glut. max, med and min., and the more deeply located piriformis, obtur ext. and int., the two gemelli and the quadratus fem

The muscular plate of the *glut max* extending from superior posterior to inferior anterior will upon elevation of the thigh suffer a change in the direction of its fibers which, especially in the middle section tend toward a horizontal course

Only the uppermost bundle in which the point of insertion has been approximated is shortened, but the lower most bundle which has been directed upward from its horizontal course is elongated The more or less exaggerated horizontal displacement of the glut max. is important, because its function in association with the other pelvi trochanteric muscles, of keeping the pelvis in a horizontal position on the standing leg is interfered with The *glut med* is exposed to a shortening to even greater degree than the glut max. rise perpendicularly from the greater trochanter to the anterior portion of the iliac crest while the posterior half of the muscle spreads fan shaped upward and backward to the middle portion of the iliac crest. The upward displacement of the trochan

ter causes an approximation of the sites of insertion of the muscle, which significantly interferes with its function as a pelvic support. The *glut min*, which sends out its bundle of fibers in fan-shape from the greater trochanter to the middle gluteal line of the dorsum ilii, plays a less significant role as a source of power Owing to its close relation to the capsular hood, it is dilated with the latter by the upward advancing femoral head There can, therefore, be no question of any shortening of this muscle. In general, the practical significance of these changes occurring in the glutei lies not so much in any change in length, but rather in a *change in the direction* of their fibers.

As regards the more deeply lying pelvi-trochanteric muscles, (*piriformis, obturator ext* and *int*, *gemelli* and *quadrat fem*), these present a more or less horizontal course All of these muscles change their horizontal course into a vertical course and are accordingly subjected to a corresponding extension and *elongation*

The *ileopsoas* muscle is worthy of special mention, since its course between the iliac spine and ileopectin tubercle to the lesser trochanter is involved to a special degree. If the femoral head has proceeded upward and left the socket, the ileopsoas tendon will, at first, suffer a relaxation because its point of insertion in the lesser trochanter is likewise displaced upward This relaxation naturally results in a nutritive shortening of the muscle If, however, the femoral head advances still farther upward along the external surface of the ilium, then the lesser trochanter is displaced in the same direction and the tendon still further approximated to its point of insertion on the lesser trochanter The tendon, however, no longer extends downward toward the lesser trochanter, but turns about the anterior margin of the pelvis, like a string about a bundle, to reach the upward dislocated lesser trochanter behind the ilium and in this way contributes considerably to constriction of the isthmus. The ileopsoas must then naturally undergo considerable stretching and elongation. Even when the tendon escapes outward from its groove between the inferior spine and ileopectin tubercle, the conditions of tension show very little change At the site where the ileopsoas courses over the anterior wall of the pelvis an enormous bursa may be formed

Turning our attention now, to the *pelvi-femoral* and the *pelvi crural* muscle group, we find much less complicated conditions. Here, we have only to consider the group of the adductors, i.e. the adduct. magn., brev., and long and the pectinus. The upper portion of the fan-shaped adduct magn., extending toward the linea aspera of the femur follows a course almost parallel to that of the axis of the femoral shaft With elevation of the femora therefore, the upper portion of the adduct magn. suffers a change *in course only whereas the middle and distal muscle bundles* undergo considerable shortening

The pelvi crural muscles include the sartorius, tensor fasciae latae and rectus fem., inserting on the anterior side of the femur the gracilis inserting on its internal aspect, and the semimembranosus, semitendinosus and biceps femoris, inserting at the tuber ischium and extending along the posterior aspect of the femur These muscles run almost parallel with the femoral axis. The approximation of the points of insertion will be equal to the degree of upward displacement of the femoral head, with a corresponding shortening

As regards the *trophic* condition of the musculature, this is considerably affected, especially in older patients with dislocation In *the gluteal muscles the changes are so striking* that Verneuil was led to believe that C D H was a purely paralytic condition. However, this atrophy of the gluteal muscles is only secondary and a result of functional devastating process in the involved muscles. Also the other muscles show a slight atrophy, involving not only the musculature of the thigh but also of the leg This is much more obvious in unilateral cases because the musculature of the normal side is usually hypertrophied owing to the increased functional demand

In *teratologic* dislocations, the condition of the musculature is quite different Here we have as a rule to deal with marked contractures, present even in the newborn infant In the arthrogrypotic cases the consistency of the muscles resembles that seen in *ischemic* contractures *The muscles are considerably* reduced in volume and frequently adhere to [illegible] The contractive elements have been largely [illegible] by tissue fibrous bands.

8 Blood Vessels and Nerves

The large vascular and nerve trunks running a course nearly parallel with the axis of the femoral shaft, behave in a manner similar to that of the long muscles, and in more advanced cases, undergo nutritive shortening with the progressive elevation of the femoral head The elastic vascular tubes adapt themselves without difficulty to the elongation incumbent upon reduction. The nerves, however present a different problem, and in particular the sciatic nerve, the function of which may be impaired due to excessive stretching

In summarizing the results of the numerous investigations of the pathology of typical C D H, it may be stated, for the time being, that aside from the atypical dislocations, C D H presents certain anomalies which do not correspond to those observed in a traumatic dislocation joint and which may in part appear contrary to these The anomalies of the congenital hip joint in the adult cannot be regarded simply as further extrauterine developments, or as excerbated by extrauterine factors but must be considered as postnatal acquisitions due to the mechanical consequences of dislocation

Chapter V

ETIOLOGY

THE ETIOLOGY OF C D H HAS ALWAYS BEEN OF INTRIGUING interest to orthopedic surgeons and has for many years been the object of ardent studies and discussions. The dearth of adequate factual material explains the almost confusing number of theories that arose on a purely speculative basis. There is hardly a single constituent of the joint or periarticular, or even distant bodily regions, which has not at one time or another, been considered as having some etiological significance in this disease In our opinion, only those theories are worthy of consideration, which can be brought into harmony with the development of the pathologic anatomy of C D H Nevertheless, for the sake of completeness, we will briefly review these earlier theories.

A OLDER THEORIES

Among the causes of C D H were included

1 Acute trauma
2 Arthritic processes
3 Disturbances of muscular antagonism

With regard to the first of these the trauma signified was that of injury to the maternal abdomen This is the oldest of all theories, reaching back to the days of Hippocrates. It was reported by Verduc, Pare, Petit and Cruveilhier and had also numerous later advocates such as Chatelain Kleeberg Phelps, Sidney Jones, Barth and others. However the last mentioned authors stipulated that trauma could be regarded as having etiological significance only in isolated not in all cases Other possible forms of trauma included birth injuries Petit Verduc Smellie and Capyron considered the latter as responsible for some cases Chelius and D Outrelepont for all cases

Valette and Nelaton soon opposed the traumatic theory and also Roser Hofmokl Kroenlein and Lorenz registered potent

objections to it. Attention was directed to the fact proved in numerous experiments on the cadaver, that the alleged injury might truly cause fractures and epiphyseal detachments but never dislocations, and in particular not without rupture of the capsule. Furthermore, this theory was questioned because of the absence of symptoms of traumatic luxation.

Regarding the second etiological factor mentioned, Parise, Malgaigne, Pravaz and others described arthritic processes as the cause of C D H These writers had in mind a simple joint effusion or similar inflammatory processes J L Petit mentioned rickets in etiological relation to C D H and believed that a rachitic swelling of the acetabulum drove the femoral head from its socket. Sedillot claimed the cause of luxation to lie in a primary relaxation of the ligamentous articular apparatus. Even much later, some authorities adhered to this conception (Perthes, Peltesohn, Bradford) As a matter of fact, flaccidity of the ligaments is a commonly observed condition in newborn infants. However, it is only rarely seen in combination with C D H

As for the third possible cause mentioned above, the theory of a disturbance in muscular antagonism was in its time the object of heated discussion According to this theory, dislocation was the result of a flaccid or spastic paralysis Verneuil incriminated a flaccid paralysis of central origin, developing during fetal life or in early infancy as the cause of C D H Verneuil's pupil, Reclus, was an eager advocate of the paralytic origin of C D H, and even went so far as to assert categorically that paralytic luxations were congenital. Bouvier, Broca and Volkmann at once rejected the Verneuil theory The intensive study directed shortly thereafter to spinal infantile paralysis, proved once and for all that C D H and poliomyelitis have nothing to do with each other

Guerin proposed the theory that C D H, as well as congenital deformities in general, is due to *spastic* contractures of the muscles, which, in turn, are caused by diseases or defects of the nerve centers. Guerin based his theory chiefly on some findings in monsters, as well as on the incidence of multiple contractures and luxations associated with defects of the central nervous system Certainly, muscle spasms have not lost their significance

as an intrauterine cause of congenital deformities. Also the paralytic conditions developing in severe cases of spina bifida and myelocele may occasionally produce a luxation

Even though, today, these older theories must be regarded as finally rejected, this does not mean that one of the factors listed may not *occasionally* constitute the real cause. Thus we find repeated mention of traumatic luxations occurring during delivery Furthermore some fetal diseases may lead *to dislocation.* However in such cases, the newborn infant will show traces of the preceding traumatic or inflammatory process. Some osteomyelitic processes develop before birth, leading to abscess formation and perforation and secondary dislocation of the hip Also intrauterine acquired paralytic luxations of the hip joint have been repeatedly observed In all cases the dislocation was congenital, but nothing was found to substantiate the possibility of a typical C D H with which it has nothing whatsoever in common

The most lasting impact on the study of the etiology of C D H was made by that theory, briefly *designated as the mechanical theory* It is based on the assumption that C D H develops as a result of the forced position of the fetus in utero Since this theory has some advocates even today, we will discuss it more fully

B THE MECHANICAL THEORY

In order to understand more perfectly the mechanical processes, which according to this theory may lead to dislocation of the hip it is first of all necessary to consider the *normal development* of the hip joint

According to Petersen it is only in the fifth week of intrauterine life that a differentiation of the femoral anlage becomes manifest in the centrally somewhat more densely cellular blastema of the limb bud When the femoral diaphysis has reached the stage of primordial cartilage, one may detect the first traces of the pelvic anlage *The femoral head and the pelvic anlage*"—according to Petersen's description — are still densely crowded cell masses which cannot be definitely distinguished from each other The spine is still spatially separated from the pelvic anlage Thus the pelvis develops *independently* for each side

but in *one piece* on each side *in continuity* with the skeleton of the limbs. Between the three nerve trunks (cruralis, obturatorius and ischiadicus), three processes with more densely massed cells presently emerge, each containing a chondrified nucleus The chondrification of the pelvic anlage thus begins in separate centers, corresponding to the later ileum, ischium and pubis Also the femoral head contains such a cartilaginous nucleus, whereas the primordial anlage was the same for all

Each of the three chondral nuclei of the pelvic anlage now continue to grow predominantly in two directions The nucleus of the dorsal segment grows toward the vertebral column, finally joining the lateral mass of the sacral spine. The two ventral segments unite with each other to form the foramen obturatorium, and above this, with those of the opposite side, to form the symphysis. On the other side, the three chondral rays unite in the acetabulum, the margins of which later chondrify to form the base.

The femoral head is attached to the pelvis by abundant fibrous masses inside and outside the acetabular margin By these fibrous masses springing from the mesenchymal cells, the bands about the margin of the joint are transformed into a capsule. That portion of them, however, which is intra-articular and unites the cartilaginous joint bodies, later disappears to make room for the joint space. Liberation of the joint occurs toward the end of the third lunar month Thus, *ontogenetically, the joint surfaces differentiate earlier than the joint space (Bernays)* De Santo and Colonna also arrived at similar conclusions on the basis of their studies on normal fetuses from 6 to 30 weeks of age.

In the third lunar month — once again relying on Petersen s findings — the pelvis shows a very marked transverse spañ, corresponding to the marked increase in width of the sacrum in relation to the small size of the other pelvic bones The acetabulum appears entirely lateral and shows considerable depth although relatively *shallow* as compared with conditions in the newborn infant.

The femur is in the beginning a straight thick rod the femoral neck and trochanter being as yet only suggested, the axis of the femoral neck still forming a negative angle of 10 de-

grees (retroversion) with the transverse axis of the knee joint. Even *before* the development of the joint space, the position and shape of the femur undergoes considerable transformation From an initial position common to all vertebrates (Huxley) there gradually develops the complicated lever system of the skeleton of the extremities (Braun, His)

In man, following differentiation of the first "anlage" the thigh is in abduction and rectangular flexion The extensor surface of the thigh with the patella turns outward and the knee joint is flexed Following termination of the change in position the thigh is in adduction rotated inward and even more markedly flexed. Since the change in position takes place *before* the development of the joint space, it cannot be caused by a movement *in the joint but only by a transformation of the femoral shaft*

Von Friedlaender has made a more careful study of this transformation and has shown that the adduction movement causes bending of the femoral neck toward the shaft producing the *angle of the femoral neck*, and the inward rotation produces an introtorsion of the thigh corresponding to normal *anteversion* Finally the third change caused by the movement consists in the production of an initially absent antero-posterior bowing of the femoral shaft having its vertex in adults, about the level of the lesser trochanter and which Friedlaender has designated as "*anteflexion*" of the coxal end of the femur

We will now discuss those theories which presuppose mechanical influences or a chronic moulding trauma as the cause of luxation

The first contribution of this order hails from Dupuytren He believed the assumption justified that with marked *flexion position* of the femur pressure is exerted by the femoral head against the posterior and inferior parts of the joint capsule leading to luxation The presumption here was a deficient amount of amniotic fluid combined with a simultaneous pathologic weakness of the tissues.

Roser expressed the opinion that C D H *was caused by an* abnormally marked and abnormally protracted *adduction position* of the flexed thigh in utero and that this position was due

to a deficient amount of amniotic fluid. In this position, not only the outermost and hindermost portion of the capsule was dilated, but also the corresponding portion of the acetabular rim was flattened Roser offers as a proof of the truth of his contention the fact that in young children luxation can be reduced by abduction, whereas adduction manoeuvres cause reluxation. He draws attention to the pressure marks found on the abdomen above the os pubis, and refers to analogous pressure marks in other cases of intrauterine pressure deformities, such as club foot.

Likewise Tillaux, Shattock and Lockwood consider the forced position of the limbs, in utero, responsible for luxation Also Lorenz, who at first subscribed to the mechanical theory, considered with Reiner, the continued flexion-adduction position of the thigh as a sort of chronic trauma, causing the gradual transformation of the plastic acetabular margin, which is held responsible for the tendency to luxation

Hirsch, who agrees in the main with the opinions of the above mentioned writers, searched for the luxating force and believed it to lie in the innate growth energy" of the fetal femur Schanz attributed the luxation *and* the bowing of the femoral neck to one and the same mechanical cause Schanz imagined the process to consist in the formation of a two armed lever by the thigh in adduction-flexion position finding its fulcrum in the inguinal flexure and causing a forward and downward bending of the femoral neck If this force persists it will pry the femoral head out of the acetabulum, forcing it against the posterior, inferior portion of the capsule. Codivilla proceeds from the normal position of the fetus in which the thigh is flexed on the abdomen and rotated so far outward that the legs are crossed. The increase in pressure caused by oligohydramnion now causes an approximation of the knees, with adduction and inward rotation of the femurs. The inward rotation of the distal end of the femur then produces an inward torsion of the proximal end, and the acetabulum simultaneously becomes more perpendicular and more shallow If, then, in postembyronic life, the leg is extended the upper end of the femur appears to be turned outward In this case, the joint has but slight stability the forward inclining femoral head

and the shallow perpendicular acetabulum favoring the upward displacement of the thigh in the direction of muscular pull The strain of body weight upon standing upright and walking contribute still further to luxation.

In Codivilla's deductions, we see for the first time an attempt *to explain upward luxation by antetorsion of the femur*

Also Ludloff considers C D H to be of purely mechanical origin and incriminates disproportion in size of the embryonic joint bodies, a condition recognized since the time of Petersen. Otherwise he inclines toward the conception of Dupuytren and Roser who attribute luxation in the presence of a relative deficiency of amniotic fluid, to forced flexion and adduction in a downward and backward direction i e. over the inferior posterior rim of the acetabulum. Ludloff, however, studied also the immediate further fate of the femoral head Following the first postnatal extensions of the thigh the originally inferior posterior luxation becomes a superior posterior luxation This path presents itself as a sort of gliding groove beginning back of the site of origin of the iliofemoral ligament rising upward at the os ilium and finally reaching a point below and beside the ant sup spine From Ludloff s presentation it is clear that the *luxation originates in utero as a posterior, inferior luxation and is transformed in postembryonic life into a superior, and finally into a posterior, superior luxation*

The prerequisite for production of an intrauterine pressure deformity or pathologic pressure effects is primarily a pathologic condition of the pregnant uterus. Since the writings of Dareste Dupuytren and Roser *oligohydramnion* has been regarded as the most common factor Other causes include changes in position of the uterus (retroflexio) and tumors The abnormal pressure effect becomes strikingly manifest in extrauterine pregnancy Sittner was able to collect from the literature a whole series of severe malformations in extrauterine fetuses, among them the case of fully developed unilateral C D H described in detail by Jerie in 1906

Preiser on the basis of a case of coincident coxa valga and anteversion in a boy of ten years of age believes with Drehmann and Springer that *congenital coxa valga* is to be regarded as a

precursor of C D H, the most striking symptom being the constantly associated anteversion of the femoral neck According to Preiser, the more marked valgus position of the femoral neck is caused by the parallel position of the thigh in utero, and the transient pressure against the sacral hollow of the pelvis At the same time, the superior rim of the acetabulum is affected by the assumed lateral pressure, i.e., the vault of the acetabulum is arrested in its development, thus fulfilling the main condition for later luxation on attempts to stand and walk Preiser offers as a proof of the validity of his hypothesis the occasional coincidence of dislocation of the hip and abdominal hernia, umbilical hernia, rectus diastasis, etc. Laterally, the abdomen, owing to the assumed constriction of the uterus, is compressed by the upward reaching legs. The viscera can be displaced only forward, and in this way, the above mentioned abdominal changes take place. Preiser, therefore, is an advocate of the mechanical theory the forced position of the fetus and intrauterine pressure—the only difference being that he believes that these constitute prerequisites for luxation deformity of the femur and a weak acetabular vault, while the actual dislocation develops after birth due to strain in attempts to walk

Vogel goes a step farther He considers the mechanical factors, i.e. the position of the extremities and pressure of the uterine wall in case of deficient amniotic fluid only as *accessory* factors, which finally lead to the production of a dislocation primarily dependent on a vitium primae formationes. The nature of the developmental defect is, according to Vogel a disturbance in distribution of the mother blastema

Also Pratje adopted a similar view and on the basis of his studies of roentgen films of dislocations of the hip, evolved the following theory of the etiology of C D H primarily one has to deal with a *retardation* of the normal course of development, not with a stand still and therefore likewise not with an actual malformation due to arrested development In cases leading to luxation, we are confronted at the time of birth as a result of the retarded development with a much too shallow acetabulum with a poorly developed rim This shallowness of the acetabulum facilitates luxation whether the latter be released directly by trauma

or by beginning function (walking and standing) or even b forced position in utero. Here too, therefore, in spite of th assumption of a primary developmental disturbance the deter mining influence of a forced intrauterine position is emphasized

As finally regards *twin pregnancies* the danger of spati constriction is not generally too highly rated, although traces o pressure by one fetus on the other have been observed ofte enough Moreover C D H is quite rare in twins. There are onl isolated cases reported by Crookshand and Norbury Sebilea Narath Lorenz, and recently by Nitsche and Arnknecht Th scarcity of typical luxations in twins, who are doubtless expos to intrauterine spatial constriction, would likewise seem to *refu* the mechanical theory

From the theories hitherto developed, one must assume th the mechanical deformation of the articular constituents ma occur very early, even at a stage of development when the join space is not yet formed On the other hand we dare not overloo the fact that positional anomalies of the extremities are frequent ly reproducible after birth and that therefore, in these cases, the have evidently persisted to the end of pregnancy

Any attempt to attribute C D H to intrauterine forced pos tion is blocked by the observation that *no particular* position deviation can be shown to be responsible and that dislocation o the hip occurs just as frequently combined with hyperextensio as with hyperflexion of the knee joint, so that ultraphysiologi positions of *different* types may be involved The positions of th extremities of the embyro show various types, even normally and the forced position is nothing other than fixation of a posi tion forced to the ultraphysiological extreme

The variations of deformity of the femoral neck combina tions with coxa vara coxa valga, and the different degrees o anteversion of the femoral neck are just as difficult to reconcil with any single position.

The mechanical theory may, therefore, insofar as it con cerns C D H be considered as disproved *If it were correct* the the luxation would develop in utero in *all* cases, because th chondral acetabular rim could present no adequate *resistance* t the pressure of the femur *Above all the fact would remain un*

explained, that in one group the infant is born with a fully developed dislocation, and another with a predisposition to dislocation

C. THEORY OF A PRIMARY DEVELOPMENTAL FAULT (VITIUM PRIMAE FORMATIONIS)

The first writer who advanced the theory that C D H was a primary developmental malformation was Verduc (1701). He assumed the "endogenous" cause of luxation to be a congenital malformation of the capsule. Paletta used only the more general term of "growth disturbance." Breshet believed that a retarded development of the pelvic bones forming the acetabulum was to blame, and that even a reduction in the size of the nutrient vessels of the os ilium would suffice to disturb the general development of the acetabulum. Also Caillard and Billionére considered luxation a "défaut du germe," a primary fault in development. Schreger, too, attributed luxation to defective "anlage" or an arrested development and progressive metamorphosis of the acetabulum.

The Ammon theory was probably the one that provoked most prolonged discussion. Ammon attributed the deformity to a persistence of the more rudimentary plate-like form of the acetabulum, and therefore looked upon luxation as a genuine example of arrested development. He even went so far as to reserve the term 'luxation' for only a small group of dislocations, preferring for the great majority of cases the designation dysarthrosis ilio-femoralis congenita. In his opinion the deformity was an "ectopy" of the femoral head, and he emphasized the fact that in some cases the femoral head did not actually move out of its socket, that, in other words there was no luxation, but had never been normally adjusted in the first place. At that time it was not yet known that the femoral head and acetabulum have their origin in a common layer of chondrified connective tissue.

So also Sainton and Cautru assumed the primary cause of dislocation to be an abnormal flatness of the acetabulum. Likewise Sayre and Adams described the primary vitium as a primary abnormal development of the joint. Wolff considered the

frequently observed hereditary transmission of the deformity and its association *with other malformations having their origin* in a defective anlage (anencephalus club foot webbing etc.) *as important evidence in support of the theory of a primary* fault of development

Later on an attempt was also made to investigate more thoroughly the nature of the arrested development Thus Dollinger advanced the theory that proper development of the acetabulum was hindered by a precocious ossification of the epiphyseal cartilage On the other hand, Grawitz was able to demonstrate that such a premature synostosis as described by Dollinger did not take place, and that on the contrary instead of a synostosis, an arrested development of the Y cartilage was the responsible factor Histologically, the faulty development was most clearly manifest at the osseo-cartilaginous margin where the normal zones of proliferation were but poorly developed. Grawitz, therefore suspected processes somewhat similar to those observed in so-called fetal rickets. However, this theory likewise had only a short survival, and was in turn replaced by the Holtzman theory, according to which luxation was considered due to a growth disturbance affecting the central blastema of the pelvic anlage and thus interfering with the development of the acetabulum within this blastema

In 1908 Le Demany initiated an entirely new and wholly *original form of investigation of the etiology of* C D H He approached the problem from the anthropological standpoint and *looked upon dislocation of the hip as related directly* to brain volume with special reference to the white race The large size *of the brain in the white race requires a broad pelvis, of* sufficient size to permit delivery of infants for the succeeding generation The large skull and excessively long thighs force the human fetus into an exaggerated folded position This leads to deformities of the joint bodies *which in turn predispose to luxation*

These deformities include principally *torsion* of the femur caused by pressure of the uterine wall The latter exerts pressure by its tonus and an even more lasting pressure by *its contractions* It keeps the lower limbs of the fetus in exaggerated

flexion, with resulting torsion of the femur To this femoral torsion is added still another abnormality a persisting atavistic anlage of the acetabulum, with an oblique forward inclination of about 20 degrees. According to Le Damany these conditions would never have had any injurious results if the human race had continued to maintain the position and gait of quadrupeds The pathological result, i.e., C D H, finds its explanation in the fact that the excessive flexion position in utero is followed, after birth, by excessive reflexion, an excessive straightening out, in preparation for the upright position With a flexed femur, the femoral head is propelled toward the base of the socket. With extension if the femur is twisted too far and the socket inclined excessively forward the femoral head moves out of the socket.

Le Damany is thus of the opinion that C D H is caused by a primary defective anlage dependent on ontogenetic development, which, if it attains a marked degree owing to poor adjustment to the upright gait, leads to luxation In the final analysis, therefore, C D H would be a *tribute of the human race to the upright gait, the predominant incidence in the female sex being explained by its anthropologic ascendancy*

The hereditary aspect of C D H can in his opinion, be explained by transmission of pelvic deformities, perhaps also of the femur

As intriguing as these conceptions of Le Damany might seem on superficial consideration, they nevertheless left one with a slight sense of deflation after the great expectations The idea of a mechanical separation of the femoral head from its socket as a result of the forced flexion position of the fetal thigh was moreover not new, but had already been used by v Friedlaender, Schanz, Codivilla as well as Lorenz and Reiner in explanation of their mechanical theories. As soon, however as Le Damany's ideas took flight into the region of anthropological strata, the terra firma of facts was left behind.

As regards anthropologic antetorsion, the findings reported by Martin in his textbook on anthropology do not coincide with those described by Le Damany Martin observed the lowest average degree of torsion in Europeans and Japanese (9°-11°), medium degrees of torsion in Negroes, Malayans, and del Fue-

gans (17 -18°), even more marked torsion is found in Patagonians and Polynesians the *maximum* average torsion (39 47) was found in the Maoris. However, in recent studies on Europeans, the individual variations in torsion were considerable (25 42°) If antetorsion had the etiologic significance ascribed to it by Le Damany these figures would indicate not the white race but rather the lower races as showing a special predisposition to luxation If as Le Damany contended the dislocation of the hip is caused by torsion of the femur and a forward inclining acetabulum, it would be difficult to understand why man in his anthropologic ascent did not adjust himself to this relatively slight developmental anomaly Furthermore there might also be an anthropological antetorsion" of the upper end of the femur but this would not necessarily give rise to an anthropological luxation of the hip joint

Also his explanation of the marked predisposition of the female sex to C D H owing to the humanisation excessive and dégénerèscence supérieure of this sex has for the time being at least no factual foundation.

Nevertheless the theory of Le Damany found serious and enthusiastic advocates in the following period including among others, Murk Jansen who in accordance with Le Damany's theory of the large brain and wide pelvic girdle, attributed C D H to simple mechanical forces. He did not however regard this as the cause of C D H alone, but also of a series of other affections of the hip joint such as coxa vara coxa plana coxa valga slipped epiphysis and malum coxae

Recently Badgley has interested himself in the problem of the etiology of C D H From his observations in six cases of arthrogryposis multiplex congenita, he concludes hypoplasia of the hip is not a primary factor in the acetabulum producing dislocation He believes that dysplasia of the hip is the result of failure of normal rotation of the limb bud due to either intrinsic or extrinsic factors, with a resultant secondary flattening of the socket and anteversion of the head and neck which may lead to anterior displacement of the femoral head "The anteversion of the head produces a secondary flattening of the socket"

In a second paper he denies "dogmatically" that there is scientific evidence of a primary genetic developmental fault of the posterior superior portion of the acetabulum, and concludes "Congenital dislocation and congenital dysplasia of the hip may be regarded as the result of faulty development, due to environmental factors extrinsic to the hip joint An inherited fault in the timing of development may produce these extrinsic changes. The loss of the normal dynamic reciprocal relationship of the component parts of the hip joint during the stage of rotational adjustment of the limb buds may produce the secondary adaptive changes which lead to acetabular dysplasia or congenital dislocation Heredity can play an important part in altering the growth and time factors. The known embryological development of the hip joint is certainly opposed to the theory of a primary inherited failure of development of a portion of the acetabulum"

Badgley describes his theory as an hypothesis, thus admitting himself that his statement was only tentative and would require further factual proof In truth what he was offering was nothing other than a repetition of the old and long since refuted theory of Le Damany The question as to how correct his theory may be as concerns the origin of arthrogryposis will not be discussed here It would be a mistake, however, to draw any conclusions from these rare arthrogrypotic cases as to the genesis of the *typical* C D H

D DISCUSSION OF THE ETIOLOGIC FACTORS

In order to arrive at some decision as to the etiology of C D H, it will be necessary first to discuss a series of problems as far as the present state of our knowledge permits.

1 Types of Luxation

As regards the types of luxation found in young infants, in whom no important secondary changes due to the strain of body-weight have to be taken into consideration, it must be stated that typical C D H begins as an *anterior superior* luxation This position may persist for months or even years Gradually the femoral head slides farther outward till it reaches the lateral surface of the ilium beside the anterior superior spine. With pro-

gressive easing of the strain and in the absence of too marked an anteversion, this phase may develop to a terminal state of iliac luxation Since only a primary *posterior* luxation can develop with the forced position in utero it is clear that such a forced position, and in particular flexion, can have *no etiological significance in the development of the primary anterior superior dislocation* or *typical* C D H It has been emphasized that in the extreme flexion position in utero which is considered responsible for the altered strain only the *inferior* half of the acetabulum would be flattened, since there would be no strain on the superior half (Wollenberg) One must in fact assume with Lorenz that the physiologic fetal position especially one associated with maximal flexion of the thigh would afford the greatest possible *protection* against the development of anterior superior luxation

It is not intended to deny the possibility of a posterior inferior, genuine congenital subluxation or luxation, which may develop directly into a posterior, superior luxation but autopsy findings of this type are limited almost entirely to teratologic cases.

2 Heredity

Every extensive investigation of the etiology of C D H has included a discussion of its hereditary aspect As early as 1678, Ambroise Paré drew attention to heredity in this disease maintaining albeit with far too great assurance that the lame not only frequently but usually give birth to lame offspring Kroenlein (1882) prepared genealogies in which luxation could be traced for generations. Similar cases were presented by Drachmann Camper Marjolan Volkmann Kirmisson Howard Marsh Lorenz Delanglade and others In his collection of more than 200 cases Vogel was able to demonstrate heredity in 30 per cent A direct transmission *from* mother to child was encountered in only six cases. The other cases were distributed over three or more generations, without any demonstrable constancy in the mode of transmission In a series of 8 610 cases, Poli observed heredity in 26 32 per cent Paternal transmission was more frequent than maternal transmission Often the *fa*

milial incidence of luxation was described as hereditary In the majority of cases, however, no distinction between familial and hereditary incidence could be demonstrated

In Japan Hayashi and Matsuoka conducted an exhaustive study of this problem They investigated several types of heredity sex linked transmission (the father transmitting the affection to his son, the mother to her daughter), crossed transmission (father to daughter, mother to son), collateral transmission (healthy parents, uncle and aunt with dislocations) and finally familial incidence (several cases of luxation in the same family with no heredity) The two writers found that in a total of 1096 cases, heredity could be demonstrated in 14 7 per cent, a familial incidence in 3 4 per cent. Paternal transmission was far more common than maternal transmission Glaessner, basing his calculations on cases reported in the literature, estimated that heredity could be demonstrated in 20 per cent of cases.

If it is kept in mind, that the luxation does not actually materialize in all cases, but remains as a predisposition in many cases, we may assume with Faber that the number of persons with only a latent form of the hereditary anlage for C D H is just as great, or even much greater, than the number in which the typical deformity has become manifest. One has, therefore, to reckon with the possibility that even in isolated cases of C D H, with apparently no other members of the family afflicted, the disease may still be hereditary As a matter of fact, Faber in his studies on nineteen families, was able to demonstrate with regard to solitary apparently non-hereditary cases that in none of the families examined was the case under treatment the only one with the stigma Each family revealed other members stigmatized with manifestations of a primary anomaly in the hip joint, in the form of various early stages of luxation up to actual dislocation. Faber was also able to demonstrate how the hereditary developmental disturbance in the hip joint was introduced into a non-stigmatized kinship through marriage.

Aschner and Engelmann believe *two recessive* hereditary anlage to be responsible for the development of C D H, and concluded from the relatively frequent coincidence of C D H with

congenital dislocations of other joints in their material that there must be a general "*luxation gene*" which works in unison with another gene provided by the momentary local disposition Isigkeit who attempted to correlate the results of his investigations with the theoretical Mendel figures assumed that for the development of C D H *two recessive non sex linked hereditary factors and two dominant sex-linked factors were required* The most probable assumption at present is that offered by von Hooff on the basis of his studies of the families of more than 1 000 patients with C D H, namely that dislocation of the hip is inherited by *dominant* transmission Whatever interpretation is accepted for the mode of transmission the *heredity of luxation remains a fact which supports the theory of an autonomous developmental disturbance independent of mechanical influences*

Subscribers to the mechanical theory see no contradiction to their views in the admitted hereditary aspect demonstrable in a certain percentage of cases, because only the disposition to a certain type of maternal pelvis or uterus need be inherited It has been demonstrated that C D H is more frequently transmitted through the father than through the mother so that the question arises as to whether the father can transmit to a daughter a disposition to pelvic sex organs which he does not himself possess

3 Predominance of Luxation in the Female Sex

Very special difficulty has been encountered in all theories in explanation of the marked predominance of the deformity in the female sex According to statistics published to date the average sex ratio is six females to one male (p 9)

H Meckel explains this fact by the assertion that the female sex is the primary sex from which the male is *differentiated* Since C D H usually develops at such an early stage that no definite sex differentiation has yet taken place and the sexual type is therefore still the primary female type this fact can be used to explain the greater incidence of the deformity in females.

In contrast to these vague inferences, opinions were soon expressed which attributed the predominance of the deformity in the female sex to special factors in the construction of the female pelvis In his extensive anatomic studies, Fehling was able

to demonstrate that the male and female pelves are characteristically differentiated by the end of the fifth fetal month The acetabulum in the female fetus is more laterally directed, whereas the concavity of the fetal male pelvis has a more forward direction The luxating force of the fetal position and longitudinal growth energy of the fetal femur, has therefore less difficulty in pulling the femoral head backward from its socket in the female than in the male, in which the femoral head is directed more toward the center of the socket. Since the factor described by Fehling is the only one based on a proper anatomic foundation, the development of luxation must logically be relegated to the second half of pregnancy As a matter of fact, the conditions determining fetal position due to lack of space in the uterus and the resulting effects on the fetal joints are present to any significant degree only in the later period of pregnancy

In contradistinction to Fehling's conclusions, Graf finds the female acetabulum constantly more ventrally inclined than in the male The disposition to backward dislocation in girls would thus be less, but the disposition to forward dislocation might possibly be increased No significant sexual differences have been noted in the angle of the femoral neck or torsion

In an attempt to clear this problem, Shiino made a study of 43 normal pelves and arrived at the following conclusions

1 All acetabular masses in the female pelvis are definitely *smaller* than in the male, evidently in accord with the smaller and more delicate female bone structure in general.

2 The depth of the socket in the female is *smaller* than in the male both absolutely and in relation to the radius of the curve.

3 As regards the *position* of the acetabulum, a sexual difference is seen only in its relation to the frontal plane. In the *female* pelvis, the acetabular axis departs slightly farther from the frontal direction, i e, the acetabulum itself lies somewhat more *frontal* than in the male.

Shiino on the basis of the material he studied, believes that certain sexual differences in the *position* of the acetabulum are demonstrable As comprehensive as his material is, however, it

would naturally be a mistake to draw any *general* conclusions from his results, not least because of the important omission of the age of the cases studied

More recent investigations on the bones of the pelvis and thigh in 100 fetuses, by W Doga revealed sexual differences in the structure of the hip joint demonstrating such unfavorable aspects with regard to the solidity of the female joint as to easily explain the predominant incidence of C D H in the female in the presence of a causative developmental disturbance

Although more accurate investigations of this aspect of the problem are lacking it may be assumed from the facts so far demonstrated that the *anatomic differences in the female hip joint favor a special predisposition to dislocation*

4 Associated Deformities

A very *important etiologic factor*, which has been utilized to support both the mechanical theory and the theory of a primary developmental defect is the occasional *combination* of C D H with other deformities.

In such cases one has to deal chiefly with serious malformations, *in particular deformities of the lower limbs, such as club foot*, contractures of the knee contractures of the hip, and club hands as well as contractures of the elbows and luxations of other joints, in particular of the knee and head of the radius. There may also be various degrees of defective development, especially of the lower segment of the spine spina bifida sacralis rachischisis etc. Even grosser malformations are encountered in non viable monsters, in anencephalus etc

Hayashi and Matsuoko have made a detailed statistical study of this aspect of the problem. In a series of 230 personally observed cases they found a combination of luxation with other deformities in 25 cases, or 10 86 per cent They also collected 140 cases of combined deformity from the literature and their report thus includes a total of 165 combined deformities Among the 25 cases in their own series deformities of the feet (equino varus calcaneovalgus valgus) were found in 15 cases and extensor contractures of the knee joint in 11 cases Among the 140 cases collected from the literature there were 12 cases of congenital scoliosis 18 cases of spina bifida 17 cases of caput

obstipum, 12 cases of abdominal hernia with eventration, 8 cases of ectopia vesicæ, 19 cases of flexion contracture of the hips, 29 cases of genu recurvatum and 78 cases of foot contractures of all known types. The most frequent deformities found in combination with luxation appear to be club foot, followed next in frequency by genu recurvatum then spina bifida and finally, caput obstipum Less obvious malformations, such as cryptorchidism, hernia, spina bifida occulta, etc. may of course easily escape detection

Hilgenreiner, in his series of 256 cases of dislocation, found associated deformities in 52 cases, or 20 per cent of his patients. These deformities included foot deformities (pes equino-varus, calcaneo-valgus, calcaneus, etc.) in 18 cases, and torticollis in 15 cases, with nine severe cases of the latter requiring operation Hernia, including three large umbilical hernia and cryptorchidism occurred in six cases, and a series of other deformities (vitium cordis, myelomeningocele, etc.) appeared in one case each Annovazzi (1925), in his study from the Clinic in Milano, found in a series of 2,500 cases of C D H only 83 cases with other malformations, or in only 3 32 per cent of the cases Of the associated deformities in his series, foot deformities were most numerous, constituting 0 68 *per cent*, while umbilical *hernia rated* second with 0 56 per cent, and deformities of the face and skull third with 0 32 per cent. Then followed congenital scoliosis angioma, inguinal hernia and torticollis with 0 28 per cent, and finally deformities of the urogenital tract in 0 20 per cent of the cases.

W Müller (1939) reported a series of 28 cases of C D H associated with other congenital deformities. He calculated that such cases of combined deformity constituted about 5 per cent of all cases of C D H He confirmed the well known fact that it is always certain definite types of congenital malformation that occur in combination with C D H Among these, he mentions web-like contractures, deformities of the spinal column, cleft formations of the spinal column, and meningocele, adduction contractures of the hips, extension or flexion contractures of the knee and elbow joints, partial dislocations of these, club foot and severe or partial flatfoot. Müller divides C D H into two types a type

of endogenous *acetabular* origin i e., due to arrested develop ment and an exogenous *dynamic* type produced by external forces causing the femoral head to move away from the socket Most of the combination dislocations belong to this latter type

The advocates of the mechanical theory find in this combina tion of dislocation with other deformities one of the chief sup ports for the validity of their assumptions and assert that since dislocation occurs in association with deformities which are most certainly of mechanical origin the luxation itself must have an analogous origin The combination of club foot and genu recurvatum point convincingly to the mechanical origin of C D H It is frequently possible in these cases to reconstruct the fetal position since many infants adopt this as their posi tion of choice for a long time after birth (Joachimsthal) Con sidering the enormous majority of non-complicated luxations as compared with these isolated cases with associated deformi ties, it would be a mistake to draw any conclusions from the lat ter as to the origin of the non-complicated cases. It can only be assumed that prenatal cases of dislocation of the hip associated with club foot and rigid genu recurvatum are actually con genital of mechanical origin and have nothing in common with the typical luxations developing after birth

It has already been emphasized that deformities are not nec essarily *constant* associations in the teratologic group and many of them may be partially or wholly absent as was apparently the case in Harrenstein s series of cases. The contention of Har renstein on the basis of this observation against any separation of the teratologic group and in favor of the embryonic develop ment of *all* dislocations of the hip must be regarded as too weak ly founded on his observation of two seven month fetuses with fully developed disl[illegible] of

It cannot be [illegible] of the above men tioned deformit[illegible] lso in combination with typical C D H [illegible] icollis. The coinci dence of conge[illegible] consider C D H as a resul[illegible] hered [illegible] lage he [illegible] of [illegible] stimu[illegible] d

position' and 'limited mobility of the fetus (size of the child, disappearance of amniotic fluid, muscular rigidity, etc.) He considers these factors to have a greater significance than the hereditary anlage."

The objection to his conclusions is the fact that an exogenous etiology of congenital torticollis has never been proved It has recently been assumed, that it is due primarily to developmental anomalies and changes in the formation of the base of the skull (Beck) Uterine pressure, therefore, could then no longer be considered as a significant factor in the etiology of congenital torticollis. If Bauer's theory were correct, the hip and knee joints, which are definitely in a forced position, would show just as severe contractures owing to muscular rigidity as are usually observed in torticollis. It is worthy of note, on the other hand, that torticollis is observed most rarely in manifestly teratological cases.

As regards the other deformities occasionally found in association with typical luxation, such as cryptorchidism, inguinal hernia and spina bifida, genu recurvatum, ped calcanei, it would seem justifiable from our knowledge of the origin of these malformations to consider them an expression of the same arrested development as that which is operative in typical C D H

It should be stated, that as a rule, typical C D H appears as a single anomaly only rarely associated with other defects, and that in the great majority of cases, ordinary dislocation is found in normal infants with no other abnormalities.

The writers subscribing to the various theories have eagerly sought to utilize the fact that children with unilateral dislocation of the hip usually have typical luxation changes also in the clinically *normal* side (p 42) Advocates of the mechanical theory explained this fact by the assumption that the abnormal position of the fetus in utero affects both sides uniformly and therefore becomes manifest on both sides (Ewald)

With the advent of Lorenz successful treatment of C D H, the latter was taken as proof *against* the assumption of a primary developmental defect, since it was quite incomprehensible how a primarily defective acetabulum could develop normally following reduction of the femoral head The answer to

of endogenous *acetabular* origin, i.e., due to arrested development, and an exogenous *dynamic* type produced by external forces causing the femoral head to move away from the socket. Most of the combination dislocations belong to this latter type.

The advocates of the mechanical theory find in this combination of dislocation with other deformities one of the chief supports for the validity of their assumptions and assert that since dislocation occurs in association with deformities which are most certainly of mechanical origin, the luxation itself must have an analogous origin. The combination of club foot and genu recurvatum point convincingly to the mechanical origin of C D H It is frequently possible in these cases to reconstruct the fetal position since many infants adopt this as their position of choice for a long time after birth (Joachimsthal) Considering the enormous majority of non complicated luxations as compared with these isolated cases with associated deformities, it would be a mistake to draw any conclusions from the latter as to the origin of the non complicated cases. It can only be assumed that prenatal cases of dislocation of the hip associated with club foot and rigid genu recurvatum are actually congenital, of mechanical origin, and have nothing in common with the typical luxations developing after birth

It has already been emphasized that deformities are not necessarily *constant* associations in the teratologic group and many of them may be partially or wholly absent, as was apparently the case in Harrenstein's series of cases. The contention of Harrenstein on the basis of this observation against any separation of the teratologic group and in favor of the embryonic development of *all* dislocations of the hip must be regarded as too weakly founded on his observation of two seven month fetuses with fully developed dislocation of the hip

It cannot be denied however that some of the above mentioned deformities occur not infrequently also in combination with typical C D H This is especially true of torticollis. The coincidence of congenital torticollis and C D H led F Bauer to consider C D H as a result of the fetal position Aside from the hereditary anlage, he regarded the responsible factor as the absence of the growth stimulus of the acetabulum owing to the "forced

position" and 'limited mobility of the fetus (size of the child, disappearance of amniotic fluid, muscular rigidity, etc) He considers these factors to have a greater significance than the hereditary anlage.

The objection to his conclusions is the fact that an exogenous etiology of congenital torticollis has never been proved It has recently been assumed, that it is due primarily to developmental anomalies and changes in the formation of the base of the skull (Beck) Uterine pressure, therefore, could then no longer be considered as a significant factor in the etiology of congenital torticollis. If Bauer s theory were correct, the hip and knee joints, which are definitely in a forced position, would show just as severe contractures owing to muscular rigidity as are usually observed in torticollis It is worthy of note, on the other hand, that torticollis is observed most rarely in manifestly teratological cases

As regards the other deformities occasionally found in association with typical luxation such as cryptorchidism, inguinal hernia and spina bifida, genu recurvatum, ped calcanei, it would seem justifiable from our knowledge of the origin of these malformations to consider them an expression of the same arrested development as that which is operative in typical C D H

It should be stated, that as a rule, typical C D H appears as a single anomaly only rarely associated with other defects, and that in the great majority of cases, ordinary dislocation is found in normal infants with no other abnormalities.

The writers subscribing to the various theories have eagerly sought to utilize the fact that children with unilateral dislocation of the hip usually have typical luxation changes also in the clinically *normal* side (p 42) Advocates of the mechanical theory explained this fact by the assumption that the abnormal position of the fetus in utero affects both sides uniformly and therefore becomes manifest on both sides (Ewald)

With the advent of Lorenz successful treatment of C D H, the latter was taken as proof *against* the assumption of a primary developmental defect, since it was quite incomprehensible how a primarily defective acetabulum could develop normally following reduction of the femoral head The answer to

this objection was that *perfect neoarthroses are possible even in a pathologic location How much easier, then, could such neoarthroses develop under the far more favorable conditions of the physiological site of the acetabulum*

Finally we must consider attempts at solution of this etiological problem by *experimental* methods. Thus Deutschlaender, like Volkman in his time, conducted experiments on very young animals in order to study the growth processes in the luxation acetabulum. The technic of these experiments consisted in opening the posterior portion of the joint capsule and following division of the lig teres, resecting the femoral head The animals were killed after one to eight months. It was demonstrated that in those acetabulae which were completely excluded from strain there developed a marked hypertrophy involving all the constituent tissues of the acetabulum and including connective tissue, as well as cartilaginous and bony tissue

It is probably superfluous to state that these and similar surgically produced luxations cannot be used in support of any theory, since aside from the trauma inflicted, they cannot in any way be compared with typical C D H in man

E CONCLUSION

In summarizing the entire etiological material our first conclusion must be that the etiology of C D H is *not uniform but completely different according to whether we are dealing with the typical or atypical (teratologic) group As long as we fail to distinguish between these two genetically different groups no clear understanding of the etiology is possible*

In comparing the indices for the etiology of the *typical* as opposed to the *atypical* cases we find

(1) A difference in the *time of appearance* of the dislocation Just so surely as the luxation in the teratologic cases occurs *in utero*, just so surely will we find that typical luxation has an *extra uterine* development This is not meant to imply that occasionally typical luxation may not be present at birth or develop during the first weeks or months after birth. Such cases

are, however, only the exceptions that prove the rule. It can be definitely concluded that all cases born with a fully developed luxation belong to the teratologic class.

(2) Typical C D H is primarily always an *anterior, superior* dislocation, developing from the upper rim of the acetabulum to lateral and to posterior superior dislocation The primary posterior inferior dislocation, which develops only secondarily into a posterior superior iliac dislocation occurs only in the teratologic group, while the position in typical C D H is primarily regularly in one direction. The position in cases with a teratologic dislocation may be different. In some cases the head was found dislocated directly upward, in others upward and backward, and in a case described by Grawitz, both femoral heads were displaced directly backward.

(3) In typical C D H, *heredity* can be demonstrated in 20 to 30 per cent of cases. Furthermore, careful roentgenologic investigations will often demonstrate a latent hereditary 'anlage' for dislocation of the hip also in apparently normal blood relatives in the form of a shallow socket. Also the constant predominance in the female sex, the varying incidence in different geographic and ethnographic regions, and the similarity of individual cases to each other, point toward an *endogenous* origin

Opposite conditions are found in the *teratologic* group A hereditary or familial tendency was not observed in any of the cases recorded by various writers As an exception might be mentioned the first indubitably teratologic case reported by Putti, in which an aunt of the child presented a bilateral dislocation of the hips. The fact that this single instance occurred in upper Italy where luxation is very common, suggests an accidental coincidence of hereditary stigma As mentioned earlier, cases of the arthrochalarotic type may appear to be familiohereditary The heredity applies however, only to the general condition of arthrochalarosis, rather than to the dislocation of the hip which is secondary Of greatest significance is also that not any sex predominance has been observed in the teratologic group On the contrary, all teratologic cases present more or less definite indications of an *exogenous* origin, usually in the

form of intrauterine pressure Especially striking are the cases with extreme deficiency of amniotic fluid as observed in fetuses of extrachorial development.

Whereas the etiology of typical C D H may be considered the same in all cases, this does not apply to cases of the teratologic group

The etiology of *arthrogryposis* is fairly obscure Rocher's theory is that the *primary cause lies in an abnormal compression* of the fetus which is followed by a defective growth of all structures concerned in the joint function. He emphasizes the history of marked oligamnios in a few cases. Also Stern emphasizes that the position and shape of the hands and feet indicate the result of a prolonged forced intrauterine position. He does, however believe that there is some form of inflammation about the joints, probably an intrauterine periarthritis with wasting of the muscles as a secondary phenomenon "It is more than likely that these cases are the result of a rare combination of both intra uterine periarthritis and intra uterine pressure

In the cases of arthrogryposis which we have observed we found no significant change in the joint or joint capsule but in all cases we were struck by the peculiar condition of the musculature, which showed a marked resemblance of consistency to that observed in ischemic contracture. It would seem plausible, that here too, one might be dealing with a similar *trophic* disturbance due to continued pressure on the vessels and nerves *supplying the joints and muscles*, as is the case in ischemic contracture and that the muscular condition produces the deformity All factors pointing to a mechanical origin are therefore in accord and we can hardly go wrong in assuming a purely *exogenous* origin for these cases. At any rate the dislocation in these cases is of prenatal *origin just as the deformities of the* hands and feet, and is like the latter to be considered as a coordinate symptom of the same teratologic condition

An origin dependent upon endogenous *and* exogenous factors must also be assumed for the dislocation in arthrochalarosis Besides the mechanical explanation afforded by *the forced position* we have probably also to assume a primary constitutional

abnormal laxity of the joint capsule and ligaments, which is most probably of mesodermal origin.

It is more difficult to explain cases associated with *defects*, especially defects of the lowermost segments of the spine and spinal cord associated with dislocation of the hip According to Feller and Sternberg, the formal genesis of these defects is not attributable to any secondary dissolution of organs at a later period of development, but to a primary defect of the organ "anlage in an early stage of development. As regards the causal genesis of these defects we are left to conjecture, and can only assume that dislocation of the hip is part of the defective "anlage," parallel to the other deformities and that most probably the cause of origin is to be sought in conditions within the germ itself This is not meant to exclude the possibility that besides the primary endogenous factors responsible for the development of the associated deformities, also secondary, mechanical, and therefore exogenous factors may play a part.

A combination of endogenous and exogenous factors may also be operative in *monsters*, since besides the primary germinal defect also secondary accessory influences may be involved In these cases, the deformities are so complex that any conclusion as to their exclusive or predominant connection with C D H would be hardly possible. It is easy to imagine, however, that a monstrous fetus might be affected by mechanical influences which would have no effect on a normal fetus.

The development of luxation as a result of *roentgen injury*, as described by Korvin, in his earlier mentioned contribution (p 25) from the Vienna Clinic, is to my knowledge the only case of this kind, and therefore deserves special mention. Also this case of C D H, owing to its combination with other deformities, and the absence of any hereditary stigma, could be classified as a case of teratologic congenital dislocation of the hip It differs, however, in many respects, from hitherto described cases there was no question in this case of any spatial constriction of the fetus. Nor could the associated deformities be wholly attributed to mechanical influences. There was no contracture, but on the contrary, a very free mobility of the hip joint. Then, too, reduction undertaken at the age of five months, succeeded very

easily, which is very unusual in teratologic cases. If we consider the well known fact of the frequent incidence of microcephaly following roentgen irradiation of the mother in the first months of pregnancy, as well as the occasional observation of bony defects in these cases (Feldweg Murphy and Goldstein, Ries) the conclusion *would seem justified that in our case the roentgen irradiation was responsible* not only for the microcephaly *the ulnar defect and the shortening of the thighs,* but also for the bilateral dislocation of the hips. One might explain this result as due to an inhibition of growth in the region of the hip joint due to the irradiation similar to that observed in typical C D H caused however, not by an inherited anlage but by exogenous radiation injury

Thus we see, that in the different types of luxation in the atypical group, *various causative factors have to be considered,* there are cases in which purely mechanical conditions produce the luxation and also cases, in which defects in the germinal 'anlage' and unfavorably acting mechanical forces cooperate to produce this effect It is only the similarity in behavior of *typical* dislocations that suggests a *common etiologic principle* which we will try to clarify

Recent observations including roentgenographic studies of newborn infants and children in the first months of life, have definitely *demonstrated* that typical C D H is as a rule no primary congenital disease but develops secondarily during the course of *the first and second year of life under the influence* of muscular action or weight bearing It is only the *disposition* to luxation that is *congenital* in the form of a *dysplasia i.e.,* a disturbance of ossification in the region of the hip joint The flatness of the acetabular *roof is* the principal anatomic feature but the genetic growth disturbance is, however not limited to the acetabulum alone. It extends also to the coxal end of the *femur and to the* entire pelvis

If in contrast to the mechanical theory we consider a genetic disturbance of *ossification it is necessary* to emphasize that we do not mean thereby the earlier mentioned vitium primae formationis, i e. a primarily defective anlage but a *retardation of growth* which is most especially manifest in the tri radiate

ı of the floor of the acetabulum Boehm considers the most
ıficant factor in producing the primary morphologic change
C D H to be the arrest of quantitative and qualitative growth
ı primitive stage of development.

At present there can no longer be any doubt as to the hereditary
ibition of ossification as the basic cause of C D H The nature
this disturbance in ossification is not known Histologic studies
iducted by Grawitz revealed marked disturbances in zones of
fication He found the zones of proliferation poorly developed
compared with the normal The cells were distributed with
ge interspaces and the level of the serially superimposed cellular
ers in the vicinity of the zone of ossification was only one
rd to one fourth of the normal level. The studies presented by
awitz included, however, only completely developed luxations
long duration and cannot, therefore, be used for any evaluation
the primary changes. So far, no histologic studies of the early
ges of luxation in newborn infants have appeared

As regards the final causes of C D H we have only assumptions.
e of these assumptions is, that we have to deal *with a hitherto known hereditary factor, which exerts a marked inhibition the normal transformation of primordial cartilage into bone*
As revealed in the various cases, typical luxations usually do
t develop until *after* birth or may *fail to develop altogether*
cording to Faber this last possibility depends upon the *reactive pacity* of the basic tissue If the disturbance of normal reactiv-
is slight, then the joint may, under the influence of functional
muli, develop normally, and such a joint would be difficult
distinguish from a normal joint at a later age. If the disturb-
ce of normal reactivity is more marked, then, in spite of
ginally normal topographic relations of the joint bodies, a
oluxation may develop or an osteochondritis, or at a later age
osteoarthritis

The reactive capacity of the basic substance will also explain e possibility of cure if the femoral head is forced to remain in e acetabulum, which, even though inhibited in its growth, may ntinue to develop until an adequate shape has been attained

In opposition to Gocht s theory that the numerous anatomic
res of C D H indicate that the basic tissue has retained its nor-

mal capacity to react it must be stipulated that besides the for tunate favorable results of reduction therapy, there are also man cases in which in spite of a normal adjustment and favorab functional conditions, the normal development of the joint fa to take place because the normal reactivity has been permanen ly destroyed or has for some reason become exhausted.

Chapter VI

SYMPTOMS

THE CLINICAL SYMPTOMS OF C D H ARE THE RESULT OF THE abnormal topography of the articular constituents. They vary according to the age of the patient and duration of dislocation Formerly only the more or less fully developed dislocation was used as a basis for descriptions of the disease Today we know that *typical dislocation develops from dysplasia*, and that there are numerous intermediary stages between congenital dysplasia and iliac dislocation, which may become fixed as permanent deformities with characteristic clinical and roentgenographic findings.

A. EARLY SYMPTOMS

In any study of the symptomatology of C D H, special attention must be directed toward early symptoms, considering the great importance of early treatment. These may usually be observed in the first months of life, and in many cases even immediately following delivery

To begin with there is a *loosening* of the hip This is related to the flaccidity of the capsule which is always associated with dysplasia, even when no dislocation has yet occurred. The loosening of the joint is manifested by a diminished active and exaggerated passive mobility Connected with this loosening of the joint, we find the second symptom of *external rotation* of the limb, as well as a laxity of the skin on the internal aspect of the thigh, where it forms deep transverse folds (Fig 36) The third and most important symptom is a certain *inhibition of abduction* which is demonstrable in the earliest stages of dislocation This inhibition of abduction is most probably due to disturbance of muscle antagonism resulting from weakness of the abductors and prevailing adductor group After the first six months, the inhibition of abduction becomes more marked, obviously as a result of the exaggerated adduction contracture. Towards the

end of the first year of life this may constitute a considerable obstacle to reduction which cannot be overcome without the use of an anesthetic. Occasionally this inhibition of abduction is combined with a slight flexion contracture. In the stage when a



Fig 36 Marked dislocation tendency of the right hip in a girl of five months. *Early symptoms* Note the outer rotation of the right limb and the deep transverse folds of the skin of the right thigh.

tendency toward luxation becomes manifest (p 53) we usually find also the sliding phenomenon which consists in an upward and outward *movement of the femoral head, upon pushing the* thigh upward and downward in a vertical direction Another symptom is the *shortening* of the leg which does not become evident until the luxation tendency is already definitely present

It is to begin with these lesser symptoms which rouse suspicions of a dysplasia The absence of all of these symptoms is however no absolute proof that a dysplasia is not present Hilgenreiner has described as a really determining symptom the so-called 'Repositionsgerausch This symptom was known since the time of Guyo and Gerdy It consists of a snapping of the hip joint (clicking hip) occurring upon active or passive move

ment. This sound can be heard most frequently and most clearly in children in the second and third quarter of the first year of life, at a time when the tendency to dislocation or dislocation is already present. Guyo is of the opinion that this sound is produced by the gliding of the femoral head over the roughened acetabulum. Judging from our own experience, however, these murmurs can not be considered as a constant symptom of C D H

To the above mentioned symptoms may be added other less important signs, such as asymmetry of the genitocrural and gluteal folds with flattening of the involved buttock Naturally these symptoms become clearly manifest in young children only when the dislocation is unilateral, and they are not exclusively characteristic of C D H, but may also be observed in congenital coxa vara. We will return to a consideration of these early symptoms in our discussion of early diagnosis

B SYMPTOMS IN OLDER CHILDREN

As soon as the child begins to walk, which is usually somewhat later than under normal conditions, toward the first and second quarter of the second year of life the symptoms become more manifest Also the symptoms of subluxation are frequently slight, and the disease picture may remain obscure for years in spite of inadequate adjustment of the femoral head in the socket. Cases of this 'larval' form of subluxation have been described by Engel and Gangolphe. Clinically one finds at most a slight limitation of abduction and increased outward rotation With increasing dislocation, changes develop not only in the external appearance of the joint area and in posture, but also in the function of the hip joint, which cannot readily be overlooked.

a) *Changes in the External Appearance of the Joint Area and in Posture* In patients with unilateral dislocation of the hip, the most striking external change is the marked *prominence of the trochanter* on the affected side, appearing as a projection and giving the impression of a raised hip (Fig 37) If the leg is in marked outward rotation, however, the lateral prominence of the trochanter will be displaced backward and will thus be inconspicuous. The flattening and broadening of the buttock on the involved side are also dependent upon this lateral displace-

ment of the trochanter The flattened buttock is visibly flaccid and flabby The characteristic bulging of the normal buttock is so markedly obliterated on the involved side that in some instances it may even appear concave (Fig 38)

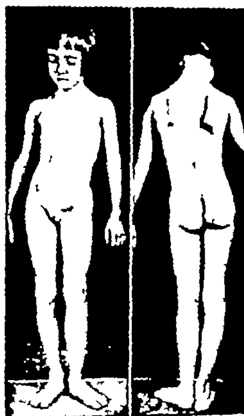


Fig 37 Left dislocation of the hip in a girl of five years seen from the front Note the shortening and outward rotation of the left limb, the prominence and upward displacement of the trochanter and the depression in the inguinal area

Fig 38 Same patient as in Fig 37 posterior view Note the flatness of the buttock and the steep course of the gluteal fold on the left side.

Also the *gluteal folds* are markedly changed, as if they had been drawn out flat and elongated This stretching of the gluteal folds is caused by the horizontal position of the glutaeus maximus, the lower margin of which determines the position and direction of the folds (p 72) The lateral portion always assumes a slightly ascending direction corresponding to the elevation of the trochanter From an anterior view there appears a change in the lateral contour of the joint area The normally present *depression* between the crest of the ilium and the prominence of the trochanter is absent and there is instead a protrusion corresponding to the upward dislocated femoral head It should be mentioned however, that in the upright position *the condition*

of the gluteal folds varies according to whether the patient actually stands on the affected leg, or attempts to spare it from pain

Another important symptom is *shortening* of the leg This is caused mainly by the dislocation as a result of the elevation of the trochanter, and is dependent upon the degree of the dislocation. In addition, there may be also an actual shortening due to growth disturbance, involving not only the femoral head and neck, but also occasionally the diaphysis as well. This actual shortening is always less marked than the shortening due to dislocation. Naturally shortening is only markedly in evidence in cases of unilateral dislocation In bilateral dislocation, it is manifest as a shortening of the inferior length, i e. the distance from the symphysis to the soles of the feet. It is thus that the primarily unfavorable proportion of the length of the trunk to the length of the legs in females may be even still more emphasized.

As regards *posture,* the child affected with dislocation of the hip presents a very characteristic picture, due to increased lordosis and the resulting contracture of the hip These changes are caused by the backward displacement of the femoral heads, and may, therefore, be lacking in lateral dislocation, or present in only very slight degree.

In bilateral iliac dislocation, one is usually impressed by the horizontal position of the posterior surface of the ilium, connected with this we find the hideous protrusion of the buttocks (Fig 39) *This symptom is the manifestation of the exaggerated* frontal inclination of the pelvis, which may often assume considerable dimensions. The increased frontal inclination of the pelvis signifies a tilt in the axis of the body in about the middle of the trunk, which in turn, requires compensatory counter-adjustments both above and below the main angle for maintenance of equilibrium. Above, compensation is undertaken by the lumbar spine, which assumes a pronounced *hyperlordosis* and in combination with the frontal lowering of the pelvis, causes the abdomen to protrude forward. Below, the compensation is attained by flexure position of the hip joint. In cases with diminished mobility of the lumbar spine or with a very marked backward

displacement of the point of support equilibrium can be maintained only by compensatory flexion also of the knee joints. These adjustments lead to the well known *zigzag* posture comprising no less than four turns in the axis, namely in the lumbar

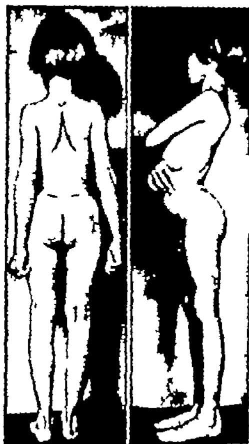


Fig. 39 Bilateral congenital dislocation of the hip in a girl of seven years. Posterior view. Marked hyperlordosis due to backward displacement of the femoral heads and increased forward inclination of the pelvis.

Fig. 40 The same case as in Fig. 39 seen from the side. Note the zigzag posture due to the compensatory hyperlordosis and flexion contractures of the hips.

spine and knee joints with an anterior convexity and in the hip and ankle joints with a posterior convexity (Fig 40). The shortening of body height in such a child due to upward dislocation of the femoral head *is considerably increased by the flexion* of the hip and knee joints, so that the body appears short and thickset. The striking diminution in length of the lower portion of the body as well as the hands reaching almost down to the knees, contribute further to the general deformity.

The axis about which the *pelvis turns* is determined by the mid point between the two femoral heads and in *bilateral* dislocation therefore if the dislocation is equal on both sides, it lies

in the frontal plane. In *unilateral* dislocation, the axis is inclined It forms an angle with the frontal plane, the vertex of which is directed toward the normal side, and the degree of which is determined by the degree of posterior displacement of the dislocated femoral head Furthermore, it forms an angle with the horizontal plane, the degree of which depends upon the vertical displacement. Thus in unilateral dislocation, the pelvis is lowered symmetrically obliquely forward, leading to more marked protrusion of the abdomen on the side of the dislocation and a depression of the homolateral inguinal flexure. The fact that the frontal pelvic inclination is greater than normal also in unilateral dislocation, explains the exaggeration of lumbar lordosis also in unilateral dislocation, although this lordosis never reaches such a marked degree as in bilateral dislocation

b) *Functional Disturbances* The most striking symptom of C D H of a functional nature is the *limp* It usually becomes manifest upon the first attempts of the child to walk

A whole series of exhaustive and informative treatises on limping in general, and on the limp of dislocation of the hip in particular, have appeared (Hoffa, Lorenz, Reiner, Gocht, Saxl, Storr, Weil and others) The chief cause of limping in C D H is the functional weakness of the abductors of the hip joint, in particular of the glutaeus medius and minimus. We have already referred, in the chapter on pathology, to the functional changes in these muscles caused by approximation and displacement of their points of insertion (p 72) This in itself affects muscular function in such a way, that the latter is diminished to a fraction of its normal efficiency If a patient with unilateral dislocation of the hip is asked to stand on his *normal* leg and to raise his dislocated limb forward with flexed knee, the pelvis on the side of the supporting leg will be elevated by the force of the above mentioned glutaei of the sound side i e, lowering of the pelvis on the side of the swinging leg will be prevented. The pelvis thus forms a two-armed lever, the flexation point of which is represented by the hip joint of the supporting leg (Figs. 41 and 43)

If, on the contrary, the patient is asked to stand on his *dislocated* leg and to raise his normal leg then the pelvis tilts to that side. Simultaneously the patient, in order to maintain the equilib

rium of his upper body is forced to throw the body toward the side of the dislocated limb (Figs 42 and 44)

This contralateral tilt of the pelvis is a never-failing most striking symptom of C D H Its symptomatologic significance was



Fig. 41 The same case as in Figs. 37 and 38 Standing on the right *normal* leg The pelvis is kept in horizontal position on the leg by the abductors Trendelenburg's sign negative.

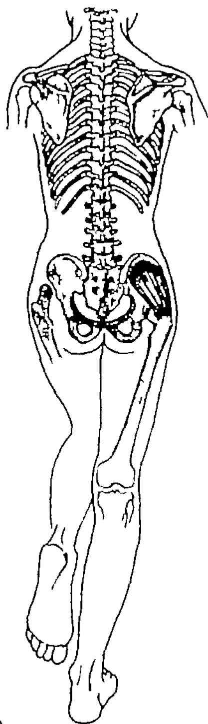
Fig 42 The same case as in Fig 41 In standing on the left *dislocated* leg the normal side of the pelvis descends. Simultaneously in order to maintain equilibrium the body weight lists to the dislocated side Trendelenburg's sign positive.

first correctly recognized by Trendelenburg and it has for this reason been named for him.

Moreover this symptom is not characteristic only of dislocation of the hip, *per se*, since it signifies nothing more than a motor weakness of the gluteus medium and minimus, which is present also in other diseases of the hip joint in which the glutei are weak as it is in cases of the neck of the femur and paralytic con

Fig 43 Explanation of Fig 41 In standing on the *normal* right leg the pelvis is maintained in the horizontal position by tension of the abductors of the hip

Fig 44 Explanation of Fig 42 In standing on the *dislocated* left leg the pelvis, *owing to the fact that* the abductors of this side are weak descends on the normal side and the spinal column deviates towards the dislocated side



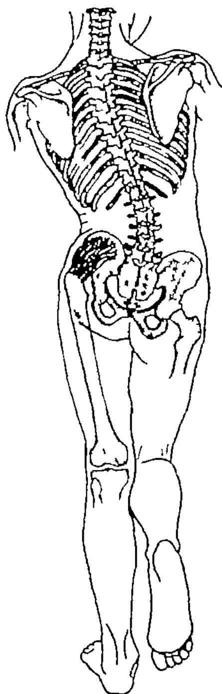


Fig 43

Fig. 44

(See legends opposite page.)

ditions involving the glutaei *The great significance of the Trendelenburg sign lies in the fact that it is not only the most reliable evidence of a dislocation but also the most important, albeit not exclusive cause of the characteristic pathologic disturbance of gait in dislocation*

The described phenomenon takes place at every step whenever the dislocated leg serves as the supporting leg and manifests itself at that moment as a tilt of the pelvis toward the swinging leg on the normal side, with a simultaneous sudden lateral inclination of the upper body toward the side of the dislocated supporting limb *The characteristic gait of dislocation of the hip is, therefore nothing other than the regularly recurring Trendelenburg phenomenon in the standing phase of each step* Attention must be drawn to the fact however, that the Trendelenburg sign may be present even though the patient may be able with the aid of his muscle power to conceal the effects of the sign to a certain degree while walking

The degree of the lateral excursion is increased still further by the fact that the pelvis is supported by or suspended from the femoral head at a point of the trunk farther lateral than normal Accordingly for the same reason, the lateral movement will be more extended in order that at each step the center of gravity of the body may be brought into alignment with the supporting line of the standing leg

Another characteristic peculiarity of the gait in patients with dislocated hip is the movement of the upper body upon raising the dislocated leg in a *vertical direction* (glissement") During the standing phase the trunk seems to collapse to some degree This movement is a result of the deficient bony support of the pelvis, and is terminated only upon maximal extension of the elastic suspension These vertical gliding movements of the femoral head on the lateral pelvic wall are plainly visible during any strain on the affected side

The dislocation gait is thus composed of three components 1 contralateral tilt of the pelvis 2 lateral lunge of the body toward the side of the dislocated limb and 3 the vertical gliding movement of the affected limb

The *shortening* of the leg, regarded by the laity as the chief cause of the limp, ranks etiologically last, since even the most complete correction of the shortening will not prevent limping, as the latter is dependent upon a functional disturbance of the dislocated hip joint

The peculiar quality of the gait in dislocation is usually described as 'waddling, and in fact, the lateral excursions of the trunk in bilateral dislocation do suggest the movements of a duck Its real characteristic is, however, not so much the lateral pendular motion, which is seen in all functional defective hip joints, as in coxa vara, paralysis of the hip, etc., but is rather the vertical gliding movement specific to dislocation, which gives the gait the character of a pump-lever-gait. It must, however be emphasized that this gliding movement is by no means a constant symptom of C D H, and that it disappears the moment the femoral head has found a sufficient bony support in the pelvis due to formation of a neoarthrosis.

It is a well known fact that the features of the dislocation gait become considerably less marked during dancing or running etc. The last mentioned peculiarity is due to the rapid shifting of movement, which renders a more exaggerated lateral excursion of the body weight superfluous On the other hand it has been observed, that during fatigue the limp becomes exaggerated Naturally, also pain which develops regularly during the course of years in unreduced dislocations, will significantly affect the type of gait.

Among the causes of limp in dislocation we have mentioned first the motor insufficiency of the glutaeus medius and minimus. This is also responsible for another regularly observed sequel. The tilt of the contralateral half of the pelvis, will, owing to problems of equilibrium and to the fairly solid union of the pelvis to the lumbar spine cause a simultaneous inclination of the lumbar spine toward the side of the swinging leg When the body is supported on the affected leg, the lumbar spine describes a wide convex curve toward the opposite side. In unilateral dislocation this curve becomes gradually fixed the convexity being directed toward the normal side, and in this manner there may

develop a lumbar, contralateral *scoliosis*, which is usually combined with a compensatory countercurve in the dorsal segment of the spine

Thus it is clear that *insofar as their effect on the lumbar segment of the spine and direction of the lateral deviation are concerned* the purely static factors play a subordinate part as compared with the functional factors. The pelvic tilt due to dislocation of the femoral head would lead one to expect a lumbar scoliosis with the convexity directed toward the dislocated side Instead of this, owing to the intervention of functional factors we find a scoliosis toward the sound side Therefore a more marked degree of scoliosis will usually not develop unless *there exists a special predisposition to idiopathic scoliosis independent of the dislocation*

In bilateral dislocation assuming the femoral heads to be at a uniform level, the lateral deviation to both sides will be equal thus producing an exaggerated mobility of the lumbar segment of the spine rather than scoliosis. Finally, in unilateral dislocation one has to take into consideration the mode and manner in which *the shortening of the dislocated limb affects the gait* In more severe degrees of dislocation the patient usually manages to compensate by placing the foot in equinus position frequently resulting in over correction of the shortening This is related to the well known fact that a more marked equinus position requires much less exertion than a slight equinus position Very frequently the knee joint on the normal side is enlisted in attempted correction *of the difference in length* As a rule this is accomplished by flexion of the knee, although the knee is maintained in flexion in the act of walking only in the presence of *extremely marked* shortenings, whereas in standing compensation by flexion of the knee is very common

To this equinus position is added the exaggerated outward rotation of the leg This outward rotation is maintained also in *the sitting position*, and as a matter of fact most patients sit with their thighs in marked outward rotation and their legs crossed

c) *Other Symptoms* The *syndrome of* C D H also includes *changes in mobility* of the dislocated hip joint In newborn infants and young children with a tendency to luxation the mobil

e dislocated hip joint is markedly increased Especially s in adduction far beyond normal limits are possible, dislocated leg can easily be transferred to the inguinal the opposite side, the trochanter and even the femoral au being palpable through the soft parts at the ilium As regards the increased flexion excursion, Pravaz had already noted in young children with dislocation that with knee extended, the foot could be brought almost up to the face. Also both inward and outward passive rolling movements are exaggerated On the contrary, abduction is considerably limited even in the early stages of dislocation (p 105) The resulting tense stretching of the innermost cords of the adductors is immediately recognized as an obstacle to abduction.

Of great importance are the *adduction and flexion contractures* of the dislocated hip joint which develop in the course of time. The adduction contracture is ushered in by subluxation of the femoral head, and is further favored by atrophy of the abductors. Furthermore, the contralateral tilt of the pelvis in walking is a factor contributing considerably to increased adduction and to the development of adduction contracture. Hand in hand with the adduction contracture, there develops a flexion contracture As a result of the exaggerated frontal inclination of the pelvis, it increases with the latter, and may in advanced cases of iliac dislocation, attain a considerable degree.

Chapter VII

COURSE

THE COURSE OF C D H IS CLOSELY RELATED TO THE ANATOMIC development of dislocation As explained in the preceding chapters, typical C D H is no longer to be regarded as an intrauterine dislocation of the femoral head only the disposition to dislocation being congenital. The latter consists in an inhibition of growth and a flattening of the acetabular roof, while cartilaginous components of the joint remain primarily normal (p 41)

Such a joint is insufficiently insured against functional strain but this congenital predisposition to dislocation usually does not become effective until after birth, when the congenital otherwise physiological flexion contracture of the hip passes into the extended position Upon extension of the hip joint, the femoral head is pushed against the anterior capsule. The femoral head interposed between the floor of the socket and the iliofemoral ligament yields to the pressure by moving only slightly outward to the posterior margin of the superior iliofemoral ligament at the site where the uppermost unprotected capsule begins Here therefore in the posterior superior quadrant of the acetabulum the femoral head begins to dilate the superimposed capsule at first by passive tension of the extended soft parts and later by active muscular pull so that shortly with simultaneous elevation from the floor of the socket it rides over the upper posterior rim of the socket When the child begins to stand and walk in the beginning of the second year the weight of the body adds to the strain and serves to complete the dislocation forcing the femoral head completely out of the socket

A SPONTANEOUS CURE

The insignificant changes which may lead to anterior subluxation explain the possibility of stabilization at this stage and the fact that under given conditions, such subluxation dislocation may go on to *spontaneous restitution* The symptoms of pre

luxation may then disappear completely or there may remain in some cases only an exaggerated flatness of the socket, which frequently becomes manifest only in later life

Spontaneous cures in the stage of pre- and subluxation have been definitely demonstrated fairly frequently Le Damany, Froelich, Wollenberg Drehmann, Joachimsthal, Bradford, P A Mueller Rupprecht, Kaiser Lorenz, Kopits, Galeazzi and Annovazi, Kleinschmidt, Werner and others have all reported spontaneous cures. Jungmann (1925) was able to collect 24 cases of spontaneous cure from the literature, to which Krukenberg added three, and Reviglio four cases. Heidsieck describes a case of voluntary subluxation of the hip in a girl two years of age which was carefully observed. In this case, dislocation occurred almost exclusively at night, and the subluxation was undoubtedly related to the relaxation of the musculature during the night In one of our cases, in which treatment was delayed owing to extraneous circumstances, perfect restitution ensued and persisted for years without any treatment.

The process of spontaneous cure has been explained most variously Drehmann and Galeazzi attribute spontaneous cure to spontaneous correction of the antetorsion and inclination of the femoral neck. Weil assumes that in cases of spontaneous cure, the natural growth tendency of the upper rim of the socket overcomes the upward pull of the musculature and thus brings the head into its normal position. Ludloff's theory seems more plausible however He assumes that the femoral head, instead of passing in back of the iliofemoral ligament, passes *beneath* the insertion of this ligament, and its upward migration is permanently halted by the base of the anterior inferior iliac spine, after which, the shrinking of the superior and posterior parts of the capsule permits the joint to return to normal Faber attributes spontaneous cure to a sort of reflex muscular action, which may even be capable of pulling the femoral head back into place when it has already partially emerged from the socket.

However spontaneous restitution of subluxation still remains a rare phenomenon and it is quite comprehensible that many observers, such as Chlumsky, flatly deny any such possibility

If the subluxation persists, then the socket is subjected to the moulding influence of the femoral head and is shaped into a shallow upwardly elongated trough simultaneously exaggerating the *anteversion and inclination* of the femoral neck Vice versa, the tendency to stabilization in subluxation is greater, the more marked the anteversion of the femoral neck

It appears that *permanent subluxations* are less common than complete dislocations. Thus, in our material of 2 138 cases, we counted 494 subluxations or 23 1 per cent Although subluxations may be observed in the third and *fourth years of life* complete dislocation usually takes place much earlier during the second and third year appearing initially as a lateral dislocation.

The transition from subluxation to complete dislocation is often very rapid and this explains why the transition from sub*luxation to dislocation frequently* escapes detection (p 50) The more rapid the transition from subluxation to complete dislocation the less will the upper rim of the socket be exposed to the *leveling effect of the femoral head* and the better are the prospects that the socket will to a certain extent at least retain its depth Thus we have the extremely shallow socket of subluxation and the deeper socket of dislocation (see Fig 50) Later on however also this socket falls a victim to the devastating atrophic process.

It must be emphasized that in the further course of the dislocation, certain types may become transformed into other types. *Thus the "anterior dislocation described* by Lange as the first type shows a marked tendency to develop into posterior dislocations *(Lange s second and third type)* (p 53) The gradual transformation of the lateral into posterior iliac dislocation has been attributed to the beginning inclination of the pelvis which in turn is due to the initially *slight posterior displacement of the* point of pelvic support.

The observation has been made that in bilateral dislocation the displacement of the femoral head progresses more rapidly than in unilateral dislocation This fact can be explained to begin with by the unfavorable primary anlage of the *bilateral dislocation and* on the other hand by the lever effect produced by the listing of the body from one side to the other and which

is relatively more marked in bilateral than in unilateral dislocation In addition, in bilateral dislocation, the joint is continuously strained whereas in unilateral dislocation, the dislocated limb is spared whenever possible.

If we now consider the path assumed by the femoral head from the moment it leaves the socket, we will note that this path from the superior quadrant of the socket to its last position at the posterior ilium, is circular, or more correctly elliptical, carrying it always farther backward and upward from the socket. This course may under given circumstances be interrupted prematurely sooner or later, by formation of neoarthroses

B FORMATION OF NEOARTHROSES

It is to be assumed that the conditions for development of such neoarthroses are more favorable the greater the pressure of the joint bodies against each other This pertains in reality only to the lateral position of the femoral head along the lateral margin of the ilium Here depression of the bone and periosteal irritation may lead to formation of a superior bony wall, which forms a protecting arch above the femoral head The farther the head has migrated from its normal position, the more unfavorable are the conditions for the formation of neoarthroses, because the femoral head progressively loses its proximity to the ilium. The pressure of the bones against each other is released the moment the pelvis and the body are suspended by the soft parts, as in a strap from the proximal end of the femur The slight protrusion of the ilium towards the external labium of the iliac crest finally offers a sort of support for the dislocated head, which limits its migration Usually, however, this external limit is not attained and the head remains in the shallow trough in the external iliac fossa, owing either to a slight depression formed at this site, or to a finally developed resistance to strain by the suspensory ligaments, which prevents further yielding to the upward pull It is necessary to emphasize the fact that this process does not always occur uniformly even in one and the same person and we gain the impression that a certain acceleration or retardation of the process corresponds to certain developmental periods of life

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C. COURSE DURING CERTAIN DEVELOPMENTAL PERIODS OF LIFE

We have already earlier drawn attention to the fact that there are certain evolutionary periods of development, that play a part even in the development of the normal joint and which therefore, have special significance for the course of dislocation of the hip. The accelerated growth processes during these developmental periods explain the frequently irregular course. These periods include the first period of development towards the end of the *first year* (period of first dentition), when the whole skeletal system is involved in an active bone construction and a second period towards the end of the *sixth and in the seventh year* (period of second dentition) during which the epiphyses of the skeletal system are in a state of most active transformation and finally the period of *puberty* with its accelerated metaphyseal growth. It is clear that these developmental periods of such great significance even for normal bone development, have even greater significance in joints affected by dislocation and manifest themselves partially by accelerated formation or decomposition of bone substance. Thus at the end of the first year of life, we may observe an increased bone formation in the nature of a spontaneous cure, after which bone formation is suspended until the sixth year. Following this, there is a marked increase in epiphyseal growth of the base of the socket and in the femoral head. Finally at the time of puberty accelerated growth may involve chiefly the femoral head thus significantly exaggerating the disproportion between the femoral head and its socket.

Aside from these special growth periods, the symptoms depend to some extent also upon *constitutional* factors as well as the individual condition of the musculature.

As regards the *shortening* this aspect of the disease is less predominant in the first years. Weight bearing aggravates the shortening. In bilateral dislocations, even if unevenly developed on the two sides it is of relatively slight significance. Only toward the end of the second decade when shortening due to retardation of growth is added to the shortening of dislocation it may reach

a considerable degree, even up to eight and ten centimeters, and may then, in cases of unilateral dislocation become a serious factor

The degree of *limping* is also somewhat related to the growth periods. As a rule children with a congenital predisposition to dislocation of the hip begin to walk later than normally (usually in the fourteenth or fifteenth month of life) This can be explained by the relative muscular weakness as well as instability affecting the involved hip from the beginning Frequently these children limp very markedly, not only when they first begin to walk but also considerably later on Following the end of the third and fourth year, the gait improves as a result of improved function of the musculature. In adolescence, the gait usually becomes worse, and in advanced age, a renewed improvement may be noted The latter seems coincident with finding of a firm support by the femoral head at some point on the lateral wall of the pelvis. The time of this development will of course vary in different individuals. Otherwise the improvement may also be attributed to a gradual adjustment of the individual, who learns to control his muscles to better advantage, and thus to partially compensate the functional disturbance. On the other hand, as the shortening progresses, the gait becomes more and more affected.

Endurance in walking may for a time be fairly satisfactory In severe dislocations, and in aged individuals, this endurance is, however markedly reduced, with associated fatigue on walking As a matter of fact the dislocation patient suffers from exaggerated fatiguability which often increases to exquisite pain which may persist for days following some occasional exertion Besides these pains due to fatigue, the patient is usually subject to sudden attacks of pain resembling those of an acute coxalgia In this condition the entire joint area is extremely sensitive and the entire musculature of the joint is in a state of reflex spasm as in beginning coxitis Even the joint itself is spastically fixed Following cessation of such an attack one may frequently observe a rapidly increased shortening

According to Halsted, 21 per cent of patients with dislocation of the hip suffer pain We have often seen patients suffer for

months at a time The cause of such pain may be attributed on one hand to traumatic traction on the joint capsule and ligamental apparatus, and on the other hand to the inflammatory irritation of the periosteum about the insertion of the capsule At any rate patients with dislocation who do not suffer intermittent attacks of pain are the exceptions. Most of them are subject to constantly recurring pain For this reason the cure of dislocation of the hip is not merely a cosmetic problem, but a problem of eminent humanitarian significance.

No special predisposition to specific diseases can be said to have been observed in the dislocated hip As a matter of fact, one *may frequently be impressed by the infrequency of tuberculous* coxitis in dislocation children as compared with those not so affected *In a series of 1373 cases of dislocated hip Lorenz found* not a single case of coxitis Jouon explains this by the fact that in dislocation of the hip there is no such intimate contact of the joint surfaces, and that in general, bones with growth disturbances are rarely affected with tuberculosis. Possibly also the deficient blood supply to the femoral head and neck would interfere with the development of a tuberculous focus.

Nevertheless, no real immunity of the dislocated hip to tuberculosis can be claimed A whole series of cases have been described with complicating tuberculous coxitis (Rouvier Guerlain Boudet, Delanglade, Gangolphe Redard and others)

Arthritic processes are by *no means rare in the secondary* joint and frequently develop also in the hip that is not dislocated as a result of congenital dysplasia or *due to continuous* overburdening of the normal side (Gaugele) Hart has drawn attention to the interesting fact that many postclimacteric changes in the hips in women producing the picture of regenerative osteoarthritis, may frequently be attributed to an undiagnosed asymptomatic congenital dysplasia

D COURSE OF TERATOLOGIC DISLOCATIONS

The course of the *teratologic* cases *differs from that of the* typical cases insofar as the latter always appear fully developed at birth, and for this reason are hardly subject to further changes. The femoral head in such cases is already at birth in a supra

condylar position, and later ascends only very slowly, or not at all

There is, in addition, an inhibition of mobility, which is not of articular origin only but is dependent also upon the tension of all the soft tissues, and which hinders any further upward movement of the femoral head Only very rarely does an iliac luxation develop Those cases which were iliac from the beginning, persist as such without further displacement on the ilium Here, therefore, we see neither a significant increase in dislocation nor marked secondary changes. Frequently there may be a considerably enlarged socket, in which the superior quadrants of the femoral head may still find shelter As a rule, the femoral head is markedly reduced in size and may be difficult to differentiate from the femoral neck. The rigidity of the muscles and contracture of the hip, which is very marked already at birth, become more marked in the course of years, so that usually the hip becomes fixed in rigid outward rotation and flexion The course differs somewhat in the flaccid cases, which from the time of birth show a marked loosening of the joint and thus likewise extreme degrees of dislocation The ability to walk in all of these cases will naturally depend also to a great extent upon the number and degree of associated deformities

Chapter VIII

PROGNOSIS

WITHOUT PROPER TREATMENT, THE PROGNOSIS OF C D H IS nearly always unfavorable A favorable prognosis may be possible in those rare and exceptional cases in which spontaneous healing occurs in the first initial stages of the disease, but such a result cannot be relied upon and is usually not lasting Aside from this slim possibility of transitory spontaneous recovery in early infancy one may expect a progressive exacerbation beginning with the period of functional strain The dislocation will make headway in direct proportion to the duration and degree of pressure, or functional strain the progressive dilatation and loosening of the capsule and ligaments and flaccidity of the muscles. According to Hilgenreiner, prognosis is adversely affected by the early or later deformation of the femoral head and neck, which usually depends upon the degree of the primary disturbance. Other unfavorable prognostic factors include the marked retardation in appearance of the osseous nuclei of the epiphysis of the femoral head and the onset of the first signs of osteochondritis before operation.

Even the neoarthroses which occasionally form in complete lateral or posterior dislocations, offer only a poor substitute for the normal joint, and are hardly capable of counteracting the *multiple difficulties presented in more* advanced cases. For this reason C D H, although initially apparently innocuous, must be regarded as a serious and treacherous disease

The prospects as far as treatment is *concerned will depend* primarily upon the *age* of the patient since the degree of dislocation and of secondary changes increase with age while the reactivity of the basic substance and therefore also the capacity for functional adjustment, diminish with age This pertains, in particular to the fifth and sixth year of life after which period the therapeutic prospects dwindle In general the fifth year is

considered as the upper age limit for successful closed reduction in bilateral dislocations, and the sixth year for unilateral dislocations. This difference is explained by the fact that the primary anlage of the whole pelvis is much less favorable in the bilateral cases than in the unilateral cases, in which at least one side has remained normal.

Naturally we do not mean to imply that reduction should by no means be undertaken in cases beyond these age limits, but the results obtained will not, by far, approximate those obtained by early treatment. After the tenth year, dislocations with very rare exceptions, may be regarded as irreducible. Undoubtedly prognosis is most favorable when treatment is applied within the first year of life. Therefore treatment should be instituted at this age without regard to any external circumstances.

Another factor of importance in evaluating prognosis is the *degree of dislocation*. The greater the elevation of the femoral head and the greater the shortening of the soft parts, the greater will be the resistance offered to reduction. A large portion of the difficulties consists in secondary changes (adhesions, constriction of the capsular sac, etc.). In our experience the iliac dislocations are beyond the limits of reduction. In the second place, prognosis will depend upon the *shape of the acetabulum and upper end of the femur*. In particular, the *depth* of the acetabulum presents a determining factor for primary stability. This is best demonstrated roentgenographically although it should be emphasized that the roentgenogram may not always yield reliable results in this respect, since retention of the femoral head is dependent not only upon the bony formation of the socket but also upon the cartilaginous layers, the limbus, capsular conditions, etc., which cannot be seen in the usual roentgenogram.

As regards the upper end of the femur many writers consider a pathologic *anteversion* as an unfavorable prognostic factor. But we know from experience, that even considerable anteversion is compatible with retention of the femoral head, and Hohmann has reported very good results in anteversion. This

fact could also be anatomically demonstrated in a specimen from a bilateral dislocation obtained two years after reduction, in an interesting case reported by Mueller In spite of severe anteversion the femoral head in this case was quite firmly retained in its socket, and could not be moved upward or downward. Drehman and others have assumed that anteversion improves following reduction This question has not yet been fully clarified, but we agree with Putti that the significance of anteversion in prognosis and treatment has been greatly exaggerated. However true it may be that anteversion does not have the determining influence ascribed to it, marked anteversion in combination with other unfavorable conditions (excepting shallow socket, deformed femoral head) must be regarded as prognostically unfavorable.

In general it has been our experience that a well formed femoral head and neck are associated with a well formed socket However, this experience is not unconditional At certain stages of development, there may exist a marked disproportion between the femoral head and the socket. Thus, frequently toward the *fifth or sixth year of life we may find a wide, roomy dislocation socket with a relatively tiny femoral head whereas towards puberty, the femoral head occasionally develops rapidly* and the socket shows a retarded development It is evident that *such disproportions between the head and socket must have an* unfavorable prognostic significance Nevertheless, all the above *mentioned* factors do not permit any unequivocal reliable prognosis in all cases. Thus we are frequently confronted with cases in which, in spite of exceptionally favorable conditions, treatment fails completely whereas other cases with an apparently hopeless prognosis may yield ideal results.

Whereas the prognosis of typical dislocation under certain conditions is generally favorable the prognosis of *teratologic* dislocations is poor from the beginning Thus the apparently paradoxical statement of Springer that the results of reduction are less favorable in infancy than later in life can be explained. Until a few years ago only severe teratologic dislocations were diagnosed and treated at such an early age The treatment of teratologic dislocations is not so hopeless, however

as might generally be expected In our own and foreign material we found a number of satisfactory cures. Nevertheless, all of our irreducible dislocations in early infancy belonged exclusively to the teratologic group

If we attempt to discover the cause of these unfavorable prospects, it is to be found partially in early developing secondary changes, like those seen later in typical dislocations. Furthermore in teratologic dislocations, there is an extraordinary atrophy of the soft parts, which for instance, in the arthrogrypotic type, may attain such a degree that they interfere not only with retention but with reduction maneuvers as well. In many of these cases one has to deal with severe combined deformities, which so dominate the picture that prognosis is more dependent upon them than upon the dislocation of the hip itself

Chapter IX

DIAGNOSIS

A EARLY DIAGNOSIS

EARLY DIAGNOSIS WITHIN THE FIRST YEAR OF LIFE IS A PREREQUISITE for prophylaxis and early treatment. Hitherto, diagnosis in early infancy has been relatively rare owing to the very slight clinical manifestations of dislocation at this age and to the greater difficulties of early diagnosis in this prone stage as compared with later on when the child is up and about. At this later stage the definitely marked functional disturbances in addition to the changes in shape are an aid to diagnosis. In bilateral dislocation there is the added difficulty of no opportunity for comparison with a normal side Also the restlessne of these tiny patients often interferes with proper examination rendering illusory any accurate test of the actual condition

The first information of importance is that to be gleaned from the mother's history of the child's symptoms. The constant observation of the infant by its mother is often more fruitful than the occasional examination by the doctor The mother may have noted that the child keeps one leg turned outward and moves it less frequently than the other leg Or in another case the dissimilarity of the adductors and genitocrural folds may have been manifest There may often be a real or apparent shortening of the limb the former due to growth disturbances, the latter to an oblique position of the pelvis Very often other children in the family have dislocations. Not infrequently infants are brought to the orthopedic clinic for other relatively unimportant deformities, a slight varus or calcaneus, and the dislocation is discovered only upon more careful examination

Hilgenreiner has contributed a few practical suggestions for early diagnosis To begin with the finding of a *"loose hip"* is of importance This manifests itself as a marked outward

rotation and an abnormal mobility of the femoral head during passive movement. Of like importance, is the *limitation of abduction* of the thigh with flexed hip and knee joints. According to Hilgenreiner, the latter is the most frequently encountered clinical symptom, even though not quite unequivocal, since it occurs also in coxa vara and in Little's disease As a matter of fact, this inhibition of abduction may be observed very early in the first months of life. Less reliable, in our experience, is the "Repositionsgeräusch," i.e. a snapping sound on abduction or adduction movements of the flexed thigh following reduction, since it is demonstrable only in the presence of subluxation.

Other symptoms of aid in early diagnosis include the *sliding* ("glissément") of the femoral head as described by Dupuytren. The child lies on his back with outstretched limbs. The examining hand on pushing upward, feels the lack of any rigid resistance which occasionally amounts to an actual gliding This lack of resistance indicates at once a deficient bony support of the femoral head, and reveals the tendency to dislocation Under certain circumstances, in restless children, it may be preferable to make the test for gliding with the thigh flexed at right angles. For this purpose, the examiner stands on the side opposite to the limb to be examined, and grasps with the fingers of one hand the region of the crest of the ilium, while the other hand pushes the thigh upward parallel with its longitudinal axis with graded force Here too the sensation is less that of any actual upward movement of the head than the absence of bony support

Savariaud has drawn attention to the leg *shortening* which is manifest quite early if the child is placed in a sitting position with extended legs. This shortening can be demonstrated by a comparison of the level of the two patellae and can be explained as due to the action of the muscles running from the pelvis to the thigh In the sitting position they exert traction, which in the absence of any bony resistance to the femoral head in the acetabulum, causes shortening Similar examinations directed toward demonstration of an eventual shortening have been recommended by Baron Demant and others.

Ettore has described a very simple method of examination. It consists in crossing the dislocated limb over the other leg Whereas in the presence of a normal hip joint, the leg can be brought only barely beyond the knee joint of the opposite side in dislocation it can be brought over the middle of the thigh and frequently even beyond the upper third of the thigh

It must be emphasized that all the above mentioned symptoms are no absolute diagnostic indication and that a negative result does not necessarily imply the absence of a beginning dislocation

When clinical examination involves difficulties, and in all suspect cases, roentgenography should be employed Roentgen examination is of such importance in early diagnosis that its omission must be regarded practically as "malpractice" whether due to gross ignorance or neglect on the part of the physician By such negligence the opportunity for early treatment may be missed We will return to a discussion of roentgen diagnosis later on

B DIAGNOSIS IN OLDER CHILDREN

Whereas in young children diagnosis may be very difficult in older children it is, as a rule, quite simple. In cases of marked dislocation, the condition may be recognized by observation of the local changes in the region of the buttocks. The flattening and broadening of the cheeks of the buttocks, the outward direction of the lateral margins of the gluteal folds, the usually exaggerated prominence of the trochanter present as a whole a picture which by itself suggests the presence of dislocation Diagnosis may be supported by the demonstration of an increased frontal inclination of the pelvis and in unilateral dislocation also by a lateral tilt of the pelvis. The characteristic curious gait of these patients will frequently suffice for diagnosis, and a positive Trendelenburg sign affords further confirmation (p 112)

Diagnosis is only definitely confirmed however by the demonstration of the *absence of the femoral head in its normal site and its presence at an abnormal site*

A number of maneuvers for examination have been suggested to render the femoral head in its new position accessible

to palpation (Roser Malgaigne, Bouvier Deprez) All of these are based on the assumption that in flexion position, or in flexion adduction position, the dislocated head will appear on the ilium This assumption will not apply in all cases, as explained in the preceding chapter In cases of subluxation in the presence of only slight shortening, the head is barely palpable on the ilium.

Lange's idea of using the well known topographic relations between the femoral head and femoral artery for orientation as to the position of the head (Fig 45) is most helpful Normally, the femoral artery passes midway between the anterior superior iliac spine and the pubic tubercle, directly over the top of the

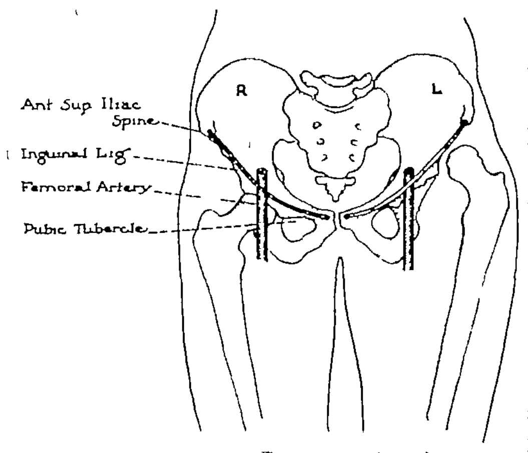


Fig 45 Topographic relations between the femoral head and femoral artery for orientation of the position of the head. Right normal hip Left: luxatio supracotyloidea. On the normal side the femoral head lies under the femoral artery midway between the ant. sup iliac spine and the pubic tubercle. On the dislocated side the head has moved out of this position (from Lange)

femoral head, and by pressure in this region, one can feel the hard resistance of the head beneath the artery Absence of this resistance indicates that the femoral head has actually moved out of the socket or has at least, lost its concentric position in the socket.

If the absence of the femoral head in its normal position has been demonstrated, it remains to ascertain the present position of the femoral head If rotary movements are performed with the leg in slight extension, with the fingers of the free hand simultaneously grasping the upper end of the femur so that *the thumb is on the anterior and the other fingers on the posterior portion*, immediately inward from the great trochanter the head can be felt definitely above the normal site in supracotyloid dislocation In luxatio supracotyloidea and iliaca the femoral head can be palpated in extension above and outward from the anterior superior iliac spine but in flexion position posterior to it. In iliac dislocation the bulge of the head can be felt protruding directly beneath the soft parts in back of the iliac spine. As a rule, palpation of the head is more successful when the rotary movements are executed with the hip joint in right angled flexion Except in the most difficult cases, the rotation maneuver will always yield information as to the position of the femoral head

With careful attention and a painstaking performance of the movements, especially in thin subjects, many anatomic de*tails such as the size of the femoral head* and the length of the femoral neck can be ascertained This is true especially in cases of *anteversion of the femoral neck In cases with no marked* anteversion, by grasping the upper end of the femur with the fingers of one hand, as described above *and the condyles of* the knee joint with the index finger and thumb of the other hand it may be demonstrated that *the frontal transverse axis* of the knee and the trochanter head axis are both directed frontal If on the other hand anteversion is pathologically exaggerated the trochanter head axis will be felt in a sagittal direction With a certain amount of practice one may even obtain some information as to the degree of the angle of anteversion Galeazzi constructed a *torsion goniometer* for deter

mining the angle of anteversion, with the aid of which the relation between the cervical axis and the transcondylar axis was claimed to be demonstrable. But owing to the fact that the measurements were taken only from the soft parts the results could be only approximately correct.

Unfortunately, clinical examination will yield no information as to the condition of the socket, because the heavy covering layer of soft tissues renders any direct examination impossible

As regards the proper demonstration of differences in length, it suffices to place the patient supine on the examining table The first orientation consists in demonstrating the equal level of the two spines. After rendering the two internal malleoli visible by slight pronation, even slight shortening is unlikely to escape the naked eye. Lorenz recommends placing both legs in sagittal flexion and thus demonstrating the shortening of the thigh even more clearly (Fig 46) More marked shortenings

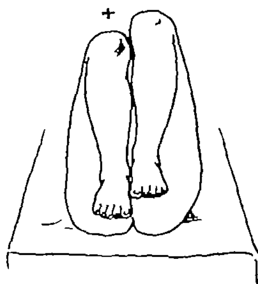


Fig 46 Congenital dislocation of the right hip Shortening of the dislocated limb is best demonstrated by placing both legs in sagittal flexion.

can be measured with a tape measure, utilizing the distance from the ant sup iliac spine to the internal malleolus. The Roser-Nelaton line is not reliable, because owing to the frequent shortness of the femoral neck, the shortening may appear greater than it really is

C. ROENTGENOGRAPHIC DIAGNOSIS

Roentgenographic examination is necessary to complete the diagnosis Today advanced roentgenographic technic permits the demonstration of delicate details of osseous changes which may serve to clinch a diagnosis, when clinical signs and symptoms are *indefinite*

As illuminating as the roentgenogram may be, and especially in the diagnosis of dislocation of the hip, it fails to answer one question which *is of great importance in these cases, namely that* of the condition of the dislocation socket It must not be forgotten that in the early stages, the skeletal parts involved in the structure of the hip are as yet cartilaginous, and will not, therefore, be visible in the roentgenogram In our opinion this in*visibility of the cartilaginous structures* has often led to erroneous conclusions. Again and again, the operative findings have differed from those indicated in the roentgenogram. Nevertheless, certain conclusions as to the cartilaginous conditions may be derived from the shape of the bony constituents of the joint

Before entering on a discussion of the roentgenology of dislocation of the hip, we believe it necessary to interpolate some remarks on the *technic of exposure* The difficulties of interpretation *of roentgenograms of the hip in infants render* imperative the adoption of certain *standards* for roentgenographic exposure To begin with roentgenograms must be taken of *both* sides for purposes of comparison even though clinically, the affection is manifestly unilateral By this procedure the slightest and earliest evidences of abnormality *may be detected It* is important, however, that both sides should be in exactly the same position at the time of exposure. It is wise to make general exposures as *symmetrical* as *possible* to obtain a picture of the entire pelvis and entire femurs including the knee joints, under nearly identical conditions of exposure Only in this manner is an exact comparison of one with the other and with the condition following treatment to be obtained

To avoid errors, the relative positions of tubes, film and object should be recorded and should be as uniform as possible In general the following rules are in order the patient should

be in supine position, and a perfectly symmetrical general exposure taken of the pelvis with *slight inward rotation of the knees* of about 10° The tube focus should be directed to the center of the symphysis or more accurately a little above the center of the symphysis.

However, a simple antero-posterior roentgenogram will yield no information as to the depth relations of the hip joint In young children lateral exposures are difficult to interpret, owing to the small size of the nucleus of the femoral head

Wohlauer, Loeffler, and others have stressed the importance of *stereoscopic* roentgenograms for demonstrating the deeper topographic relations. The great advantage of stereoscopic roengenograms in estimating the topographic relation of the femoral head to the socket, especially for the precise diagnosis of subluxation and lateral luxation, is self evident. Not infrequently, the roentgenogram will yield at first an apparently negative finding, because the femoral head lies close to the Y-line

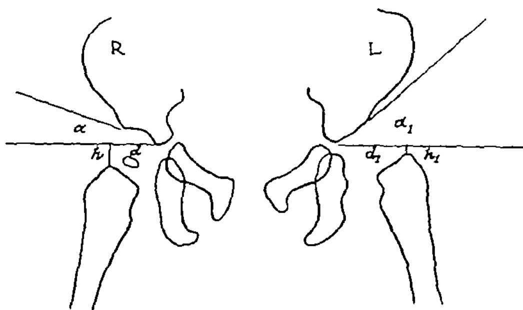


Fig 47 Hilgenreiner's lines. Congenital dysplasia of the left hip in a girl of five month (tracing of roentgenogram)

Right (normal)		Left (dysplastic)	
h	1 cm	h_1	0 3 cm
d	1 2 cm	d_1	2 cm
a	20°	a_1	40°

Only the stereoscopic roentgeneogram will show that the femoral head lies farther posterior In general however, the simple roentgenogram will yield sufficient information to render stereoscopic examination superfluous in the majority of cases.

In spite of the fact that roentgenography fails in many respects, it is nevertheless by its aid that the peculiarities in infancy which are of the greatest importance for early diagnosis may be detected Hilgenreiner (1925) has contributed very valuable material illustrating this fact and such findings may permit a decision in the majority of cases (Fig 47) If a connecting line is drawn between the two Y-lines then according to Hilgenreiner's calculations, the distance of the diaphyseal tip from the connecting line is normally 1 cm, and the distance from the diaphyseal tip to the acetabular floor 1 2 cm, the angle of direction of the acetabular roof to the horizontal plane is 20° Any deviation from these measurements from the normal figure even as little as a few mm indicates the presence of dysplasia. With the distance h d and a the roentgenogram can be unequivocally distinguished. With increasing tendency to dislocation d becomes progressively greater and h progressively less until at subluxation the latter reaches zero (Figs. 48 and 49) The acetabular angle formed between the roof of the iliac portion of the acetabulum and a horizontal line passing the triradiate cartilage was also recommended by Kleinberg and Lieberman as a helpful index for detecting hypoplasia in infants. According to these authors, the acetabular index in newborn normal infants was found regularly to average 27 5 degrees. In normal children about two years of age the index is lower than at birth with an average of 20 degrees. In an infant with a high acetabular index that is above 30 degrees, a dislocation of the affected hip will probably develop

In addition to the mentioned sign the epiphyseal nucleus (ossification center) of the femoral head which normally appears in the fifth or sixth month of life in girls, and in boys a little later (six to seven months) shows marked retardation of development In congenital dysplasia it is not until the seventh or eighth month of life that the osseous nucleus can be seen roent



Fig 48 Roentgenogram of a congenital dysplasia of both hips in a girl three months old The femoral head in normal position on both sides

Fig 49 The same case as in Figure 48 three months later showing a definite tendency to luxation on the right side.

genographically Also thereafter it remains arrested in growth The size of the nucleus, which usually develops excentric in the lateral portion of the epiphysis, will of course give no information as to the actual size of the femoral head which will be needed, but only some idea as to the degree of ossification

Another sign which aids in evaluating ossification processes in congenital dysplasia is the retardation of ossification of the *synchondrosis ischio-pubica* Normally at the time of birth, the two inferior rami of the ischium and pubis are separated by a cartilaginous zone of about 10 mm. in width, which diminishes with the growth of the osseous nucleus until toward the fourth or fifth year it is completely obliterated (Pratjes) In congenital dysplasia this zone often attains a width of 20 mm and persists to the eighth year or frequently even longer

Another early *sign* which may aid in orientation is that described by Hoffa as "*Schenkelhalsspitze*," the medial protruding margin of the femoral neck, which normally lies at the inferior margin of the acetabulum but *is dislocated upward in* case of subluxation

Other guides include Ombredanne's *vertical* line drawn perpendicularly downward from the external margin of the acetabulum, and which normally lies outside of the nucleus of the epiphysis of the femoral head but in the presence of a tendency to dislocation passes through the epiphyseal nucleus itself This presupposes, of course, that the epiphyseal nucleus is already present *in the femoral head*

In the first few months of life, i.e before appearance of the epiphyseal nucleus which, as we have stated may be considerably delayed in dislocation cases, *Menard's or Shenton's sign* may be observed, a curved line along the internal contour of the pubic bone, limiting the obturator foramen In cases of upward displacement, this curve is interrupted the lateral part of the arc being elevated

Of *great importance in determining slight degrees of change* in position of the femoral head is Koehler's "*Tranenfigur* (Tear Image) This becomes visible, however only when the infant is a few months older When a comparative film is taken of both hips, and the tube focus is directed over the middle and a little above the symphysis, there will appear in the roentgenogram in the depths of the socket a figure that suggests the internal canthus, or a tear (Fig 50) It consists of three lines, an external semi circular line (a), a *long almost straight internal line* (b), and a short connecting curved line (c) These three lines do not outline the pelvic contours but the walls the external line (a) corresponding to the wall of the acetabulum the internal line (b) to the wall of the lesser pelvis, and the short semi culcular connecting line (c) to *the semi-cylindrical corticalis* of the acetabular notch (incisura acetabuli) The tear figure is interrupted about in the middle by the Y line (acetabular synchondrosis) *of which only two* of the three limbs seen in the usual anterior posterior exposure namely those between the ilium ischium and pubis are visible whereas the third limb be

tween the pubis and ischium is covered up On the side of dislocation, the Y-line appears broader and spreads still a little more in the direction toward the socket. The synchondrosis unites around puberty and the Y-line then becomes invisible.

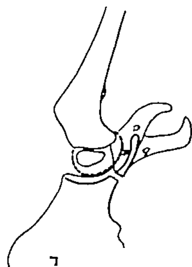


Fig 50 Koehler's *Tear Figure* Normal hip of a girl two years of age. A corresponds to the wall of the acetabulum. B. To the wall of the lesser pelvis. C. To the corticalis of the incisura acetabuli. The lowest point of the femoral epiphysis (completed by a dotted line) is at the level of the lowest point of the tear figure.

The distance of the two long lines of the tear image from each other indicates the thickness of the bony floor of the socket. Normally, in young children, this distance is 3 mm., and in C D H is greater corresponding to the greater thickness of the acetabular floor Naturally all three lines will be displaced in relation to each other, as the focus of the tube moves away from the middle of the body for this reason an accurate adjustment of the tubes over the mid-line is necessary for the correct demonstration of the tear image. With this prerequisite, one will find that normally the lowest point of the tear image is level with the lowest point of the femoral head, the contour of which is separated from it only by the cartilaginous layer of the floor of the socket. On the slightest displacement, the femoral head will appear above this horizontal line and at a greater distance from the external line of the tear fiure The shallow roof of the acetabulum can usually be demonstrated in the roentgenogram as a double boundary line, the superior, heavier one of which represents the continuation of the base of the acetabulum, and

the inferior thinner one representing the posterior rim of the socket

Wiberg recommended for *measurement* an angle, which he designated as the CE angle. If a line is drawn from the center of the head to the outside edge of the acetabulum and another line from the center of the head is brought longitudinally upward, these two lines will form an angle which normally measures 26 In the presence of maldevelopment of the acetabular roof and upward displacement of the head, the angle is diminished or negative This method of measurement is only useful however for older cases with a fully developed femoral head.

At all events a careful study *of both sides is necessary since* changes are often discovered on the clinically apparently nor mal" side which may be of significance in management of the case. Indeed the roof of the acetabulum on the non dislocated side often shows a less perfect development than on the side of the dislocation.

The diagnosis of *subluxation* is confirmed when the head lies higher up than the socket and farther removed from the latter The acetabulum is enlarged and flattened The head op posite the upper rim of the acetabulum, articulates only in the upper part of the acetabulum with its medial pole (Fig 51)

Only when the femoral head has definitely left the boun daries of the socket may we speak of *complete dislocation* The type of dislocation is still to be determined (p 53) In supra cotyloid dislocation the femoral head is projected external and superior to the acetabulum and is located at about the level of the spina iliaca ant inf In luxatio supracotyloidea et iliaca the head extends quite freely higher up and at the same time some what posterior In luxatio iliaca the head lies definitely in back of the ilium and appears more or less covered by the latter (see Fig 20)

As regards the *upper end of the femur* the roentgenogram yields much more information than it does concerning the sock et but only however, when certain conditions of exposure are met This is especially true in the roentgen diagnosis of the pres ence of a pathological *anteversion* The greater the antever

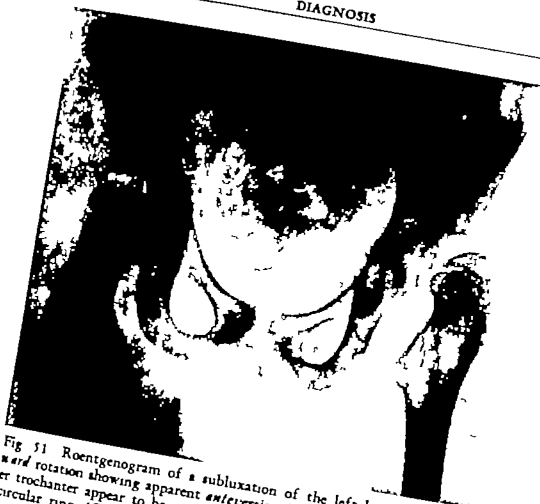


Fig 51 Roentgenogram of a subluxation of the left hip taken in slight *inward* rotation showing apparent *anteversion* The femoral head neck and greater trochanter appear to be superimposed The projection of the neck forms a circular ring (Gaugele's "*Schenkelhalsring*) Note also the greater distance between the two limbs of the tear figure indicating the greater thickness of the acetabular floor on this side.

sion the shorter and more perpendicular will the femoral neck appear in the roentgenogram. Finally in marked degrees of anteversion, viewed anteriorly the shadow of the femoral head, neck and greater trochanter are almost superimposed. A quite similar picture may also appear with normal conditions of the femoral neck during *outward rotation* of the leg on in coxa valga. To avoid error it is therefore necessary to take the exposure always uniformly with a moderate inward rotation of the knee of about 10 An accurate result may also be obtained by following Koenig's suggestion of taking two exposures in different positions of rotation one in slight rotation and the other in maximal rotation

Gaugele has drawn attention to a frequently remarkably illuminating picture appearing in cases of anteversion owing to the sagittal position of the femoral neck The most significant feature of this image is the *Schenkelhalsring*, i.e the projection of the proximal portion of the femoral neck which in the sagittal position forms a circular closed ring However this *femoral neck ring can be used as a gauge of the degree of torsion only in advanced cases.*

D ARTHROGRAPHY

Filling of the hip joint with a contrast medium for demonstration of articular and capsular relations has been described by several authors (Gocht, Borak and Goldhamer) But it was Sievers who first developed a method for the study of C D H by means of arthrography The details and interpretation of the arthrograms have been discussed by Faber Leveuf and Bertrand Severin and others. Sievers used *iodopin* and performed the filling *from a lateral approach in the region of the trochanter major*

Faber used *uroselectan B* for arthrography which presented the advantage over other contrast media of being relatively quickly absorbed (after 20 to 30 minutes) Faber gives the following rules for injection The injection needle is inserted laterally above the tip of the greater trochanter and is advanced *horizontally over the trochanter to the femoral neck* The position of the needle is roentgenographically controlled If the roentgenogram indicates a correct position of the needle within *the joint the contrast medium is injected* The amount to be injected depends upon the age of the child In infants and young children, 0 5 cc. of uroselectan will suffice in older children 1 to 2 cc. and in adults 3 to 4 cc. Following the injection the joint is moved about in order to achieve a uniform distribution of the contrast medium in the joint. Should some of the contrast medium escape into the surrounding soft parts, this is of no significance Owing to the rapid absorption of the contrast medium, the roentgen exposure must be made as quickly as possible after filling of the joint. After 20 to 30 minutes, the uroselectan will no longer be roentgenographically demon

strable. Faber was the first who demonstrated the most valuable roentgenographic features in dysplasia (p 41)

Leveuf and Bertrand recommended *tenebryl* in a 30 per cent concentration Also this substance is rapidly absorbed (in about 30 minutes) and causes no harm to the joint.

Severin uses Bayer s *perabrodil* and inserts the needle about 2 cm below the Poupart s ligament and 1 cm. lateral to the femoral artery

Rivarola and Pique recommend *nitasom* in a 50% mixture with a 1% solution of novacain A dose of 2 cc suffices for young children In older children up to 8 cc were used No serious reactions have resulted

We have employed a contrast medium which is in common use in this country, for urography, namely *DIODRAST* (a 35 per cent aqueous solution of iopyracyl), which is likewise harmless and easily absorbed (in about 20 minutes) Since the object is to get into the pocket of the acetabulum, we cannot, naturally, utilize the dislocated femoral head as a guide, but must rather



Fig 52 Filling of the hip joint with contrast medium for *arthrography* Puncture close behind the ant sup iliac spine and advancing the needle along the bone into the socket.

follow the rigidly fixed acetabulum For this reason, I selected as a site of insertion a point immediately in back of the anterior superior iliac spine (Fig 52) A three inch 19-gauge needle is used and after probing along the bone of the ilium it is advanced

about two inches to enter the socket from which synovial fluid will then escape. After the position of the needle has been confirmed by a roentgenogram, 1/2 cc. of diodrast is injected in young children or 1 to 2 cc in older children (Figs. 53, 54 and 55). This



Fig. 53. Arthrogram of a luxatio supracotyloidea on the right side in a two year old girl. Needle in place.

approach is much easier and more reliable than the anterior or lateral approach. Occasionally we have noted that reduction is particularly easy following filling of the joint.

The contrast filling gives information not only as to the position and extent of the capsular hood as well as of eventual adhesions the width and permeability of the isthmus and the form of the capsular pocket but under favorable circumstances will also yield information as to the condition and position of the limbus. The scientific significance of arthrography for our knowledge of the features of C. D. H. is unquestionable. It affords also great possibilities for practical utilization for differential diagnosis and prognostically important evaluation of obstacles to reduction (Figs. 56 and 57).



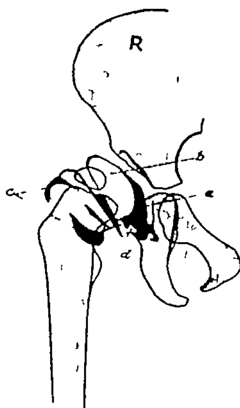


Fig 54 Same case as in Fig 53 with contrast filling *(diodrast)* Free communication between acetabulum and femoral epiphysis

Fig 55 Explanation of Fig 54 A. Contrast medium in the acetabular fossa B. Femoral epiphysis. C. Contrast ring around the femoral neck. D Lig transversum.

E. DIFFERENTIAL DIAGNOSIS

In differential diagnosis the following processes have to be considered

Congenital *traumatic* dislocation due to birth injury (obstetrical dislocation of the hip) The type of these dislocations may be differentiated from the usual types of C D H upon the basis of the history the presence of an associated fracture of the thigh, and by the roentgenographic findings. The roentgenograms show marked dislocation but the acetabulum appears normal.

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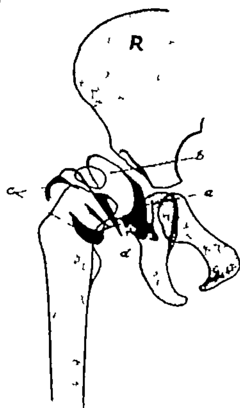


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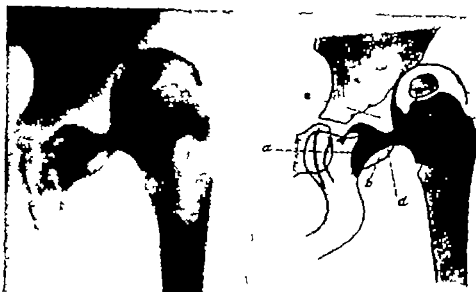


Fig 56 Arthrogram of a luxatio supracotyloidea et iliaca on the left side reveals hour glass constriction of the isthmus. Little diodrast in the acetabulum, which is filled with fibrocartilaginous tissue

Fig. 57 Explanation of Fig 56 A Contrast medium in the acetabular fossa. B. Capsular isthmus C. Contrast medium around femoral neck and head. D Lig teres. E. Well defined edge of limbus turned down.

Ruschenburg describes three cases of *traumatic epiphyseolysis* of the upper end of the femur and the differentiation of this condition from C D H Birth trauma in these cases need not be severe. Clinically there is sensibility to pressure and swelling of the thigh Roentgenologically the normal conformation of the acetabular roof excludes dislocation

There is greater danger of confusion between C D H and *congenital coxa vara* Also children with congenital coxa vara show an elevation of the trochanter, inhibition of abduction, exaggerated lumbar lordosis and a waddling gait. Examination will however permit palpation of the femoral head in the flexure of the thigh and no gliding can be demonstrated. The differentiation from C D H in young children may prove most difficult or impossible even for the most experienced A sure diagnosis can be made only on the basis of the roentgen findings. In the roentgenogram the femoral head appears at its normal site and lateral from it is the broad zone of rarefraction pass



Fig 58 Bilateral *congenital coxa vara* in a boy two years of age shows the femoral head at its normal site in the acetabulum and a broad zone of rarefaction through the femoral neck.

ing perpendicularly through the femoral neck characteristic of congenital coxa vara (Fig 58)

In *congenital defect of the femur*, the shortening of the thigh is so very marked that no confusion with C D H is possible. In cases of apparently total defect of the proximal end of the femur we are not dealing with an actual dislocation, but only with a marked coxa vara due to breaking of the diaphysis, the upper section of which is stunted and reduced to a so-called femoral cord (Fig 59)

A very similar syndrome to that observed in C D H is seen in *pathologic dislocation* of the hip, as a result of suppurative arthritis in infants. These cases are far from being as rare as gen-



Fig 59 *Congenital defect* of the left femur of a boy seven and one-half months old with congenital coxa vara on the right side.

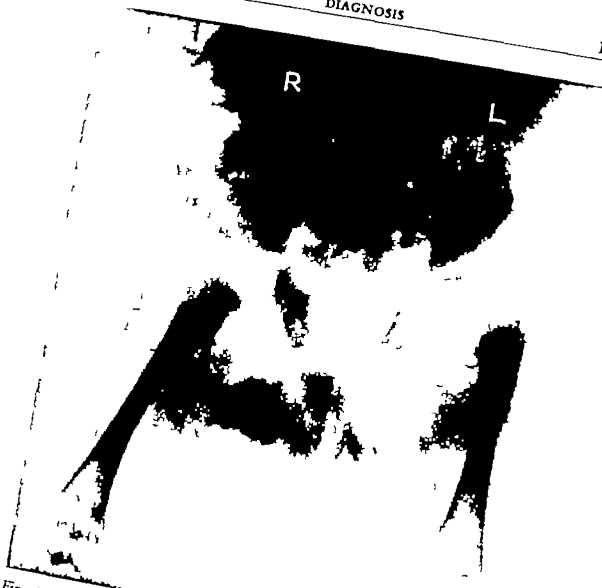


Fig 60 *Pathologic* dislocation of the left hip in a seven months old boy after acute pyogenic infection A sharply circumscribed defect of the epiphysis and neck of the femur is visible.

erally believed A destruction of the femoral head should always rouse suspicion of a pathologic dislocation This suspicion is confirmed, if examination reveals even minimal scars in the vicinity of the hip joint usually in back of the greater trochanter or in the flexure of the hip Such scars constitute signs of preceding frank suppuration with external perforation. The roentgenogram will as a rule, show a sharply circumscribed defect, or

complete destruction of the epiphysis of the femoral head, and a very marked distension dislocation of the hip (Fig 60)

Paralytic dislocation in *flaccid* paralysis need scarcely to be considered in differential diagnosis The paralytic joint is always a loose joint and is always associated with a definite paralysis of the entire lower extremity which can hardly escape detection. On the other hand a *spastic dislocation* such as occasionally observed in Little's disease, and which is due to traction exerted by the spastic adductors may be confused with C D H, especially in children who have not yet begun to walk. A painstaking examination for symptoms of Little's disease and cerebral palsy will facilitate differential diagnosis, the legs are usually crossed and the feet in equinus position The roentgenogram in paralytic dislocations will show the femoral head at a great distance from the acetabulum a perpendicular femoral neck, coxa valga and the femurs markedly atrophic in the region of the trochanters (Fig 61)

Paroxysmal pains during the course of C D H may occasionally in older children suggest a *tuberculous coxitis* Absence of fixation of the hip joint excludes coxitis. Here, too, the differentiation can be found in the roentgenogram.

Under certain conditions, the differentiation between an old C D H and an old *traumatic dislocation* may be required The secondary changes in the two conditions are very similar I had personally, on one occasion to make such a differentiation for medicolegal purposes, when a woman claimed compensation for a dislocation of the hip which she attributed to an accident experienced many years earlier It was easy to demonstrate a congenital origin of the dislocation of the hip in this case by the deficient development of the socket manifest in the roentgenogram, and the deformity of the femoral head as well as by the presence of a shallow socket on the side opposite to the dislocation

Having discussed the problem of demonstration of the presence of a dislocation and its distinction from other types of dislocation we must now consider the problem as to whether in the demonstrated presence of dislocation a *differentiation between typical and atypical* C D H is possible. This is extremely

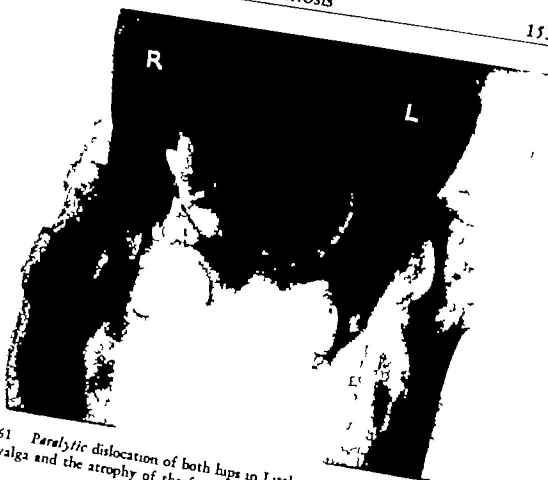


Fig 61 *Paralytic* dislocation of both hips in Little's disease. Note the marked coxa valga and the atrophy of the femoral shaft on both sides.

important as concerns the evaluation of the chances of reduction Naturally a definite differentiation is possible only by comparing all involved factors.

The high hereditary and familial incidence of typical C D H, and the definite absence of heredity in the atypical group of cases, demands special attention to the medical history Positive findings will constitute a clue, and may furnish the first bit of available evidence

Furthermore it will be necessary to ascertain to what extent in the cases under consideration the dislocation was actually congenital or developed later after birth The roentgenogram in teratologic cases will usually show a fully developed dislocation shortly after birth with advanced secondary changes both of the socket and femoral head (see Figs. 3, 4 and 5)

The third, and most important factor, is the demonstration of a combination of the dislocation of the hip with other severe anomalies of prenatal origin such as club feet, congenital defects, simultaneous dislocations of other joints, which would characterize these cases as belonging to the teratologic group whereas *minor anomalies such as torticollis and calcaneus may* also be found in association with cases of typical dislocation.

Nevertheless, the differentiation between typical and atypical dislocation may sometimes present certain difficulties, and we have to keep in mind that in many cases one or the other anomaly may be missing and that there are cases of the teratologic group which can be recognized only by the difficulties encountered upon attempted reduction.

Chapter X

PROPHYLAXIS

SINCE THE CAUSE OF TYPICAL C D H MUST BE ATTRIBUTED TO an hereditary factor, any real prophylaxis can be directed only toward the prevention of its transmission, whether by law or by instillation of an individual sense of responsibility Although we are completely at a loss to explain the actual origin of C D H as a disease linked to the gentoype of the individual, we do know that typical C D H as such is not congenital, but only the *predisposition* to luxation, in the form of a growth inhibition in the region of the acetabular base designated as dysplasia (p 15)

The existence of a state of "predislocation" as Putti called it, in all typical cases of C D H during the first year of life opened up prospects of envolving some effective method of preventing the development of the dislocation The introductory discussion of pathogenetic and etiologic theories suggests, that if the femoral head has not yet completely emerged from the acetabulum but is still partially or completely surrounded by the socket the natural growth processes may so influence the processes of adjustment of the joint bodies to each other that dislocation, as such will fail to develop This is usually what has occurred on the apparently "normal" side in unilateral C D H (p 42) The most important objective, therefore, must be to provide the most favorable conditions for such a spontaneous healing and to avoid such positions and strains in which dislocation is likely to occur

This fact has been known for a long time. Thus Lorenz recommended in cases of suspected dislocation that the hip be kept in flexion and abduction by a swaddle or bandage wrapped around the child's thigh and tied over the shoulder emphasizing the necessity of avoiding any sudden stretching of the hip Attention was also directed to the harmful effect of the custom

widely prevalent in former days of keeping infants during the first months of life tightly bandaged in a cushion with diapers between the thighs. Gaugele was able to demonstrate how the distance between the femoral heads could be considerably increased by this method In this connection, it is of interest that Nagura has attributed the relatively high incidence of spontaneous restitution of C D H in Japan to the popular habit of Japanese women of carrying their infants astride on their backs during the greater part of the day In this way the hip joints of these children were forced into marked abduction and the development of dislocation was thus prevented Froehlich was content to spread the thighs of the infant as frequently as possible by introducing a small cushion between the thighs while in bed For many years, Lance proceeded by preparing a bivalvular cast in 70° abduction and 20° outward rotation, utilizing only the anterior shell F Bauer described a spreader fastened around the thighs and attached to the shoulders by suspenders. Spitzy was able to prevent the development of dislocation by means of continuous extension in abduction position and the use of weights up to two pounds, avoiding the strain of walking or standing until after the child was two years of age. Saxl recommends the use of the posterior plaster shell as devised by Lorenz. Putti reported excellent results from his clinic in Bologna by merely maintaining the hip in abduction of 45 by means of a triangular mattress, later replaced by a metal frame with gradually increasing abduction Similar apparatus have been utilized by Forrester Brown, Leni Pogliani, Cattaneo and others However these are all clumsier and more or less complicated apparatus, even the high cost of which would exclude them from general use Hilgenreiner has described a practical splint. It consists of a pelvic girdle with two lateral wings of duralumimum available in four sizes, one for each of the first four six month periods of life The thighs of the infant which are placed beneath the two lateral wing portions are fixed to these with bands, in a somewhat diminished Lorenz primary position A similar pillow splint has been demonstrated by Frejka Quite recently Ponseti who made such good use of the Denis Browne splint in the treatment of congenital club foot has now

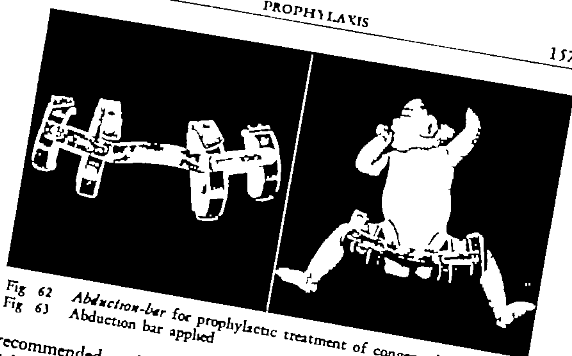


Fig 62 *Abduction-bar* for prophylactic treatment of congenital dysplasia
Fig 63 Abduction bar applied

recommended it also for early treatment of C D H Compere and Schnute have also used this treatment

A. THE ABDUCTION BAR

Proceeding on the premise that an accentuated abduction position would be most favorable for the development of the joint, since it eliminates pressure on the acetabular roof and epiphysis of the femoral head, we recommended the use of an *abduction bar* in an accentuated right angle position (Figs. 62 and 63) This bar is constructed of duraluminum and is made in one standard size. It is adjustable and is attached in front of the thighs. Since the hip joints are usually loose in dysplasia it is an easy matter to bring the limbs into the desired degree of abduction. If any resistance is offered by the abductors the bar can be bent slightly forward to permit gradual attainment of the desired degree of abduction Since the bar is applied in front of the thighs nursing and cleaning is an easy matter The bar can also be removed for short intervals for cleaning and bathing purposes, always, however with the greatest care to maintain the abduction position As a rule the duration of the treatment is about nine months, at which time the bar may be dispensed with during the day but is applied during the night, as a night splint, for another three months. This leaves the child free during the day

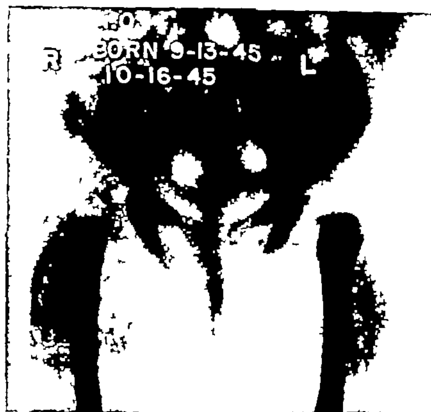


Fig 64 Roentgenogram of a congenital dysplasia in a girl five weeks old

Since there is always the possibility that the anlage is present on both sides, and that the dislocation may subsequently develop on the other hitherto clinically normal side these cases must of course be treated as bilateral

The described method constitutes the ideal treatment of congenital dysplasia However, it is not our intention to imply that the bar should be used in *every* case immediately after birth. Since the diagnosis cannot always be definitely established during the first months and many cases of slight dysplasia may develop normally without treatment it is wise to adopt an expectant attitude for the first three months. Should the findings persist, or show a tendency to progress, the bar should be applied Needless to say a treatment that dispenses with forceful manipulation anesthesia and the plaster cast means a great blessing to the little patients Another attractive feature of the method is its simplicity It must be emphasized however that this treat

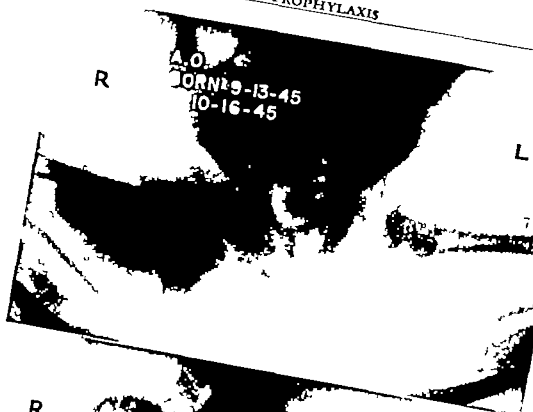




Fig 65 Roentgenogram of the same case as in Figure 64 after the abduction bar has been applied

Fig 66 Roentgenogram of the same case as in Figures 64 and 65 after nine months treatment. Note the rapid development of the acetabular roof on both sides.

ment cannot be expected to succeed in children over 12 months of age. It should also be stressed that in cases in which the



Fig 67 Roentgenogram of the same case as in Figures 64 65 and 66 at the age of 21 months. Excellent result.

ess has reached the stage of subluxation reduction and immobilization in a plaster cast are indicated even under the age of one year, because in these cases the effect of the bar is too uncertain to secure a normal joint

As regards results of prophylactic treatment there are already several reports available. Of special interest is the report published by Putti (1933) of a series of 119 cases of dysplasia discovered during the first year of life, in which a complete cure was obtained in 113 cases i.e in 94 9 per cent In a series of cases in the predislocation stage, followed up for a certain number of years, some for five years, some for ten years, Poli reported

excellent anatomical and functional results in 92 per cent, thus in almost as many cases as Putti. Naturally these figures must be accepted with some reserve, since they include many dysplasias which might possibly have gone on to spontaneous cure Hilgenreiner reports that of his 157 cases treated during the first year of life, only four, or 2 5 per cent, suffered redislocation, whereas 153 cases, or 97 5 per cent remained reduced On the other hand, results with regard to subsequent appearance of deformities of the femoral head are disillusioning In this series of 157 cases, 28, or 17 8 per cent showed osteochondritic changes These figures indicate that even the earliest treatment is incapable of preventing deformities of the femoral head.

Personal experience with our abduction bar includes 18 cases with a follow-up period of three years This is a relatively small number of cases and a rather short period of observation, but it may be stated that our results to date have fully justified our expectations. All cases show a normal conformation of the hip joint, and mild osteochondritic change was observed only in one single case We were particularly impressed with the rapid development of the joint in the early months of treatment (Figs 64 65, 66 and 67) This clearly demonstrates the extensive capacity for regeneration during the *first year of life*, whereas thereafter, this capacity diminishes progressively with age and is also subject to numerous individual variations.

B PROPHYLAXIS OF TERATOLOGIC CASES

Since many teratologic cases, especially those of the arthrogrypotic group have been attributed to intrauterine compression owing to some abnormal condition of the uterus (deficiency of amniotic fluid retroversion, tumors), it would be the duty of the Maternity Service to draw the patient s attention to the possible sequelae and to advise her to report for suitable gynecologic treatment Space-constricting tumors of the uterus, even though causing but slight symptoms in the early stages, should be removed when possible and in cases of extra-uterine pregnancy, the pregnancy should be interrupted On the other hand, surgical fixation of a uterus capable of conception should be avoided

Chapter XI

CLOSED REDUCTION

A LORENZ METHOD

THE OBJECT OF THIS METHOD IS TO BRING THE FEMORAL head into contact with the acetabulum and to maintain this contact permanently The two equally important steps in this treatment include therefore (1) reduction, and (2) retention

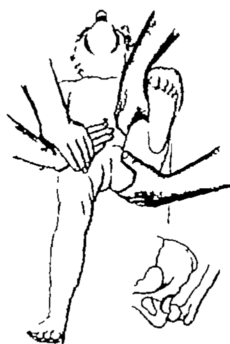
1 REDUCTION

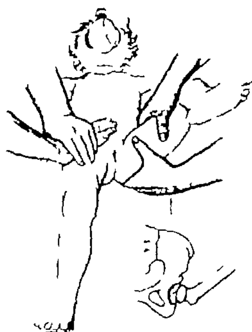
a) *Technic* Reduction according to the technic of Lorenz is accomplished over the *posterior* rim of the socket and comprises three stages

Stage 1 The anesthetized infant is placed on his back with a folded linen towel beneath his pelvis While an assistant fixes the pelvis by exerting downward pressure upon it with both superimposed hands, the operator seizes the distal end of the slightly inward rotated thigh with one hand while the fingers of his other hand are placed over the trochanter The thigh is then flexed to the maximal limit, when its anterior aspect contacts the abdomen In this way the long abdominal muscles are relaxed and the femoral head moves from its superior position in back of the posterior rim of the socket, with the trochanter serving as a pivot (Fig 68)

Stage 2 The thigh is then brought into moderate abduction by slight traction and with simultaneous outward rotation of its shaft is swung in an arch from sagittal flexion into rectangular frontal abduction In this manner the femoral head is approximated and brought to the level of the posterior rim of the socket (Fig 69)

Stage 3 Whereas the frontal abduction is cautiously increased by a slow but powerful traction in the longitudinal direction of the thigh with downward pressure to produce hyperextension an upward counterpressure is exerted by the hand on the trochanter





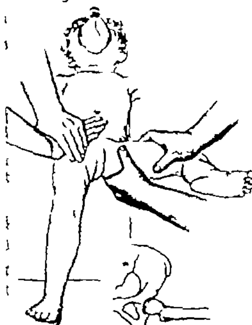


Fig 68 (top left) Closed reduction over the posterior margin of the acetabulum to Lorenz. Dislocation of the left hip *Phase* 1: the thigh is maximally flexed this forces the femoral head in back of the posterior margin of the acetabulum.

Fig 69 (top right) *Phase* 2: By moderate abduction of the thigh the latter is changed from sagittal flexion into right-angled frontal abduction. In this manner the femoral head is approximated to the posterior margin of the acetabulum.

Fig 70 *Phase* 3 By hyperextension of the thigh and counterpressure upward on the trochanter the femoral head is forced to vault over the posterior rim of the acetabulum. In this way the femoral head is brought to the floor of the acetabulum and reduction is finished.

thus forcing the femoral head to vault over the rim of the socket This maneuver finishes the reduction (Fig 70) This last manip-

ulation must be performed as gently as possible in order to prevent traumatic injury to the epiphysis of the femoral head Time and patience may be required Rectangular traction in *the longitudinal direction of the thigh should be exerted for at least three to five minutes before proceeding to the final reduction maneuver i e hyperextension and counterpressure on the trochanter* In many cases it may be necessary to render the femoral head more adaptable by rotary movements, after which it may slip more easily through the capsular isthmus.

b) *Criteria of Successful Reduction*

1 Clinical findings (*reduction phenomenon, palpatory findings, primary stability*)

2 Roentgenographic findings following reduction

Regarding the first of these criteria, reduction usually manifests *itself by a plainly visible and audible reduction phenomenon*, produced by the movement of the femoral head over a ridge and its immediate standstill in the depth of the socket The occasionally plainly audible double snap is produced by the snapping of the femoral head over the *limbus* of the socket and the immediately following and louder impact of the *cartilaginous surfaces* of the femoral head and acetabulum Frequently reduction is also manifested by a crunching grating sound produced by rupture of the capsular isthmus. The intensity of this phenomenon depends upon anatomic conditions. *If the rim* of the socket is flat and the socket is shallow or if the dislocation *was only incomplete (subluxation)*, the phenomenon will be less marked Furthermore, the reduction phenomenon will depend upon the manner of reduction Naturally the more gently reduction is accomplished the less audible will be the snap In children under two years of age it is barely perceptible Although the presence of a reduction phenomenon is desirable as a sign of accomplished reduction its absence does not justify an unfavorable prognosis as frequently suggested *In such a case one should* however take careful note as to the presence or absence of the *other signs of reduction*

Successful reduction is accompanied by other characteristic clinical symptoms in addition to the reduction snap At the moment of reduction the deep hollow in the inguinal flexure

disappears, and the femoral head becomes palpable in its normal position, as a *prominence in the middle of the groin, beneath the femoral artery* With his thumb, the examiner can feel the femoral head rolling in rotary movements Also it is noted that the thigh has become considerably longer, thus producing a tension of all the muscles of the thigh Also the knee-joint assumes a contracted flexion position, owing to tension of the hamstrings.

In doubtful cases, successful reduction should not be concluded from a single demonstration. The reduction maneuver should be repeated until the operator is convinced of a successful result. If abduction and flexion are diminished, redislocation with audible concussion will occur, with a consequent disappearance of all reduction symptoms Repeated reduction is accomplished with little difficulty, and the reduction phenomenon can be reproduced In this manner it is possible to obtain certain assurance not only of a successful reduction but also information as to the condition of the acetabular margins.

The *primary stability* of the femoral head, i.e , its immediate halt in the socket following accomplished reduction, is dependent upon the anatomic conditions of the socket and the tension of the previously shortened muscles. For this reason the Lig ilio-femorale is likewise of importance, its tension being immediately restored as soon as reduction is accomplished and of aid in retention of the head Primary stability can be demonstrated by a simple test during the manipulative procedure. If, namely the leg is released following reduction, it will, in the presence of a good primary stability, remain of itself in the position obtained by reduction. The degree of primary stability is of importance for the planning of the second stage of treatment, namely retention Otherwise the weakness of primary stability, per se, is not an unfavorable prognostic sign since complete and lasting cure is possible even when primary stability is very slight or just barely evident For this reason, the attempt of Ch Lange to base prognosis immediately following reduction upon a numerical index of the tendency to reluxation has only conditional value. After the reduction and reluxation maneuver, Ch. Lange fixes the pelvis and swings the rectangularly abducted leg slowly into flexion until the redislocation phenomenon takes place, not-

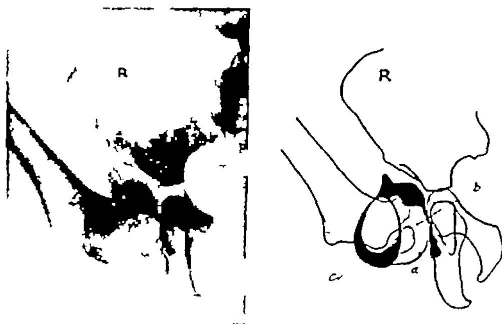


Fig 71 Arthrogram of the same case as in Figs. 53 54 and 55 taken immediately following successful reduction. The epiphysis of the femoral head lies concentrically within the acetabulum. The contrast medium has been pushed away from the fundus of the acetabulum and has collected in a ring about the femoral neck.

Fig 72 Explanation of Fig 71 A Residual contrast medium in the acetabular fossa B. Femoral epiphysis. C. Contrast medium collected round the femoral neck.

ing the angle of flexion at which the femoral head emerges from the socket He recorded an average of 25 to 30

Regarding the second criterion for judging a successful reduction, the precise relations of the head to the acetabulum at the time of reduction cannot be adequately determined without *roentgenography* The latter cannot be applied immediately following reduction, while the patient is still under the anesthetic unless a portable roentgen apparatus is available. For if the patient has first to be transported to the x ray department displacements may readily occur The position of the femoral head following successful reduction can usually be determined from a single antero-posterior exposure with the tubal focus directed a little above the middle of the symphysis. With *successful* reduction the femoral head appears opposite the infundibulum

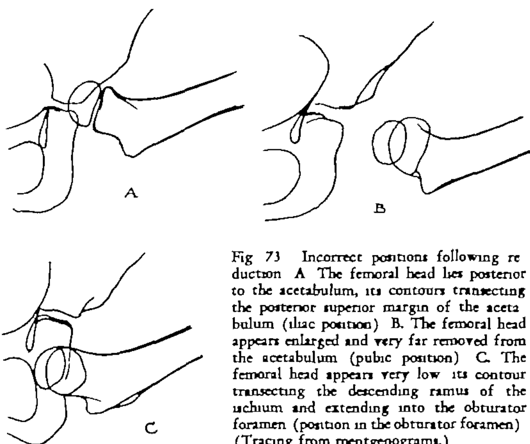


Fig 73 Incorrect positions following reduction A The femoral head lies posterior to the acetabulum, its contours transecting the posterior superior margin of the acetabulum (iliac position) B. The femoral head appears enlarged and very far removed from the acetabulum (pubic position) C. The femoral head appears very low its contour transecting the descending ramus of the ischium and extending into the obturator foramen (position in the obturator foramen) (Tracing from roentgenograms.)

beneath the transverse cleft of the Y-line, i.e , a horizontal line through the cleft of the Y-lines will touch the upper pole of the femoral head, whereas its inferior pole still remains at the level of the acetabular notch The epiphysis of the femoral head visible in the roentgenogram is separated from the external limb of the tear figure (Fig 50) by the distance of the cartilaginous surface of the femoral head from the acetabulum. This is greater in younger infants and correspondingly less in somewhat older children with more advanced osseous development. If *arthrography* has been performed before reduction, the post-reduction arthrogram will give an informative picture of the true relations and one can see whether or not closed reduction is perfect (Figs. 71 and 72)

In *unsuccessful* reduction the femoral head lies *posterior to the rim of the socket* and somewhat higher up appearing in the roentgenogram sharply defined and approximated to the socket so that its contour crosses the vault of the acetabulum and the

external limb of the tear figure (iliac position) (Fig 73A) If the femoral head has been displaced to the *pubic bone* it appears very far removed from the socket, the space between the femoral head and the external limb of the tear figure being increased



Fig 74 Technic of *axial exposure* of the hip according to Hass, to determine the position of the head in the sagittal direction.

(Fig 73B) This increased distance of the femoral head from the socket is also seen in the presence of *interposition of portions of the capsule* Putti attributes this diastasis to pericapital insertion of the capsule rather than to interposition of portions of the capsule. In the relatively rare reduction to the *obturator foramen,* the femoral head appears very low its contour transecting the descendant ramus of the ischium and projecting slightly into the foramen (Fig. 73C)

In many cases a single antero-posterior roentgenogram will prove inadequate because this does not yield information as to the position of the head in the *sagittal* direction If for instance the roentgenogram shows the head away from the acetabulum it might just as well be in front as behind the acetabulum The position could be determined by a stereoscopic roentgenogram But for routine work the author has recommended an *axial* (craniocaudal) projection in addition to the antero-posterior exposure

An axial view is taken with the hip in primary position, the tube above the hip joint, the casette below the joint (Fig 74) The value of this exposure is evident in Figs 75 and 76

The most important point is the prompt recognition of the *situation* and application of the suitable remedy Nothing is more harmful than to accept a reduction that is neither adequate nor



Fig 75 Bilateral congenital dislocation following closed reduction in the primary position A Antero-posterior exposure. On the right side the position is uncertain on the left, there is a great distance between the head and the acetabular floor B Axial exposure right head *in* the acetabulum. C. Axial exposure left the head lies *posterior* to the acetabulum

anatomic since irreparable damage may result therefrom (adhesions, etc.)

c) Obstacles to Reduction Obstacles to reduction may increase with the age of the individual Among them may be mentioned

1 Resistance of the shortened musculature
2 Resistance of the capsule and its components.
3 Bony obstacles.

Re 1 As far as the obstacles presented by *muscle* and *fascia* are concerned Lorenz has shown that the shortening affects chiefly the long pelvifemoral and pelvicrural muscles, thus offering re

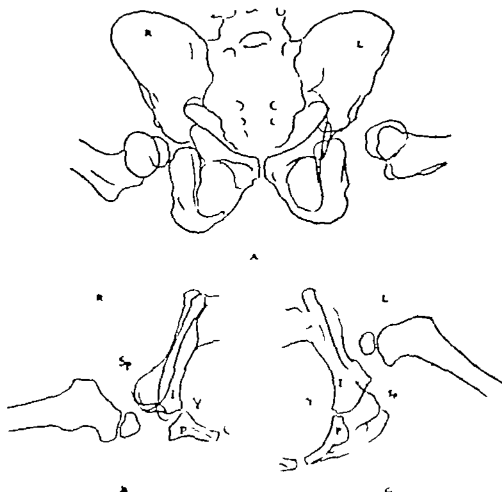


Fig 76 Explanation of Fig 75 (I) ischium (P) pubis (Y) Y line (Sp) ant. sup iliac spine

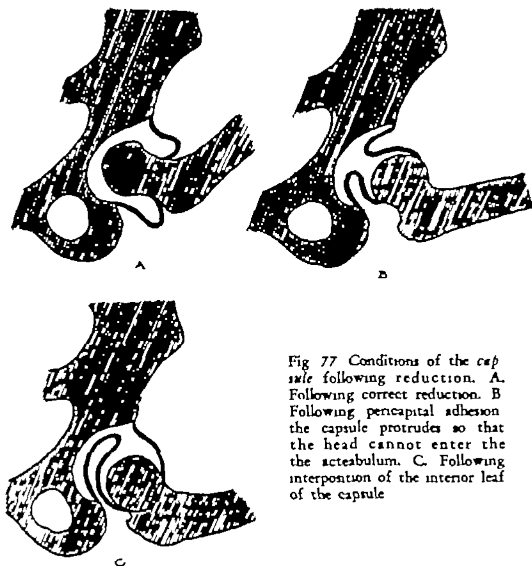


Fig 77 Conditions of the *cap sule* following reduction. A. Following correct reduction. B Following pericapital adhesion the capsule protrudes so that the head cannot enter the the acteabulum. C. Following interposition of the interior leaf of the capsule

sistance to downward pull on the femoral head. However the most important obstacle to reduction is that caused by shortening of the *adductors* This may require special measures to overcome Removal of the adduction obstacles is, moreover, necessary in order to permit an adequate abduction, which is indispensable not only for reduction but for adequate reduction

Re 2 With regard to the obstacles to reduction presented by the *capsule*, it must be kept in mind that the capsule undergoes gradual atrophy and that the superior blind sac of the capsule

the hood may form adhesions with the overlying muscles, and more particularly, with the periosteum of the ilium (Fig 77A) In addition there is the possibility of a *pericapital adhesion* of *the femoral capsular insertion* (Fig. 77B) It is especially this last mentioned adhesion which when rigid and dense may present considerable resistance to reduction or even completely hinder it, by pushing the capsule forward and preventing passage of the head. Adhesions are, however, relatively rare in early child hood *and present a problem only after the fifth or sixth year of* life at the earliest. A much more common obstacle is that pre sented by too narrow a *capsular isthmus* If the femoral head is to contact the base of the socket, it has first to pass the isthmus, which can only be accomplished by stretching of the latter Otherwise the inferior leaf of the capsule will be caught between the femoral head and the posterior rim of the socket (Fig 77C) *This interposition*, however, is found only in cases of extreme upward dislocation with a hyperextended capsular tube and extremely narrow isthmus Interposition of portions of the cap sule can be recognized by the peculiar softness of the acetabular margin and the absence of any real reduction phenomenon as well as by *the complete absence of primary stability* It can be confirmed by roentgenograms taken in the above mentioned axial exposure. The more unfavorable the relation between the lumen of the isthmus and the size of the femoral head the greater will be the difficulty encountered by the head in its passage through *the isthmus* Severin has, however in his arthrographic studies, revealed the striking fact that the femoral head can pass through even a relatively narrow isthmus. *Apparently* in many cases the manipulation which delivers the head into the ace tabulum stretches the capsular fold and widens the isthmus. In other cases the soft tissue barrier receded during the period of fixation or became atrophied

According to Putti, the pulvinar may present a serious ob stacle to reduction especially during the age period most favor able for reduction namely between the first and third years of life by preventing entrance of the femoral head into the infundi bulum which is below the Y-line.

The significance of the *limbus* in reduction has been empha

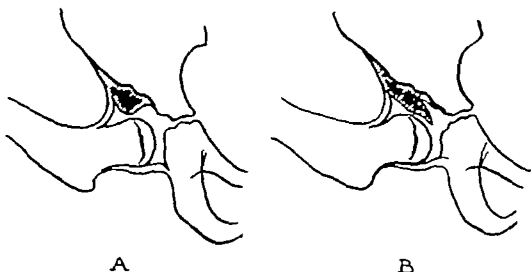


Fig 78 Conditions of the *limbus* following reduction. A The epiphysis has surpassed the margin of the limbus and is placed below the overhanging margin of the limbus. B The epiphysis has pushed the margin of the limbus forward and is separated from the acetabular floor by the limbus. Pseudoreduction (redrawn from Putti)

sized by Ludloff, Brandes, Putti, Leveuf and others The limbus plays a most important part because it forms a labium, which when turned inward in the upper quadrant of the socket, may form a serious obstacle to reduction. Complete reduction is then possible only by bringing the femoral head *below the* overhanging margin of the limbus. The femoral head may then by pressure from below upward, exert an upward and outward turning force on the limbus (Fig 78A)

If it is not possible to get the femoral head down below the inferior margin of the limbus, the head will be in the socket, but separated from the base of the socket by the limbus (pseudoreduction) (Fig 78B)

Re 3 The obstacles to reduction presented by the *bony* constituents of the joints are usually slight and relatively insignificant as compared with possible interference of the soft parts. The resistance offered by the margins of the acetabulum is never insurmountable to begin with, and furthermore favors a permanent reduction One might even consider the chances of success to be better, the greater the bony resistance. As far as the femoral head is concerned, it is true that marked deformation of the head would render it poorly adapted for entrance into the isthmus and

capsular sac, but such marked deformities are seen only exceptionally during the age period when reduction is suitable On the other hand the usual medio-posterior flattening of the femoral head is emphasized which is only of moderate help in overcoming the above mentioned obstacles.

Anteversion position of the femoral neck does not interfere with reduction if this condition is taken into consideration from the beginning Also the frequently observed abnormal shortness of the femoral neck is a hindrance only to retention

In young children up to the second or third year of life, the described obstacles are so minimal, that they are readily overcome upon attempted reduction In *older children*, however the obstacles are frequently so marked that special measures and interventions may be needed to surmount them

d) Methods of Overcoming Obstacles to Reduction In contending with obstacles to reduction the first attention must be *directed toward combatting resistance of the adductors. Removal of adductor resistance* is also of special importance because even after accomplished reduction the tense adductors may tend to force the femoral head backward and out of the socket, thus favoring redislocation Elimination of this obstacle is therefore desirable, at least to the extent of permitting the amount of abduction required for reduction Exclusion is accomplished bluntly by stretching the most prominent of the muscle fibers which are rigidly tensed in marked abduction

The most rapid method of attaining the desired result is to force the adductor insertions into prominence by marked abduction of the thigh and then apply a rocking movement to the muscle mass with the ulnar margin of the hand until this prominence disappears. This stretching is much less damaging to the *adductors* than a tenotomy for instance In this procedure one must however, avoid injuring the skin over the ridge of the adductor since *this might form a source of infection*

Gaugele appreciating correctly the role of the traction power of these muscles in primary retention recommends that the adductors be *spared* as much as possible so that the significant traction effect of this muscle group which is under maximum

extension during rectangular abduction can be fully utilized to force the head against the infundibulum Even though this advice is wholly correct, practically such a procedure is frequently not possible because in most cases abduction of the reduced thigh, so important for retention can then hardly be attained

It is particularly emphasized that all rough maneuvers for overcoming obstacles presented by the soft parts have been rejected Thus we have finally abandoned subcutaneous rupture of the adductor bundle (myorrhexis adductorum) as earlier recommended by Lorenz and also the application of the Lorenz screw for stretching of the soft tissues

Reduction in difficult cases is performed as described above with the exception that one may frequently have to increase the force of the reduction maneuver Also the desired result is often not attained with a single effort, but only after several lever movements exerted with increasing force Occasionally it may be necessary to use one s fist as a hypomochlion beneath the greater trochanter Frequently one is forced to utilize a wedge as an instrument. A wooden wedge from four to six inches high, with blunt, well padded margins is introduced beneath the trochanter to serve as a substrate, or hypomochlion, for the greater trochanter The thigh then acts as a long power arm, the femoral head and neck as a short weight arm, whereas the trochanter forms the fixed turning point or fulcrum Reduction over the wedge occurs over the posterior rim of the socket exactly as in manipulative reduction, in which the lever effect is likewise indispensable. The patient lies on his back the pelvis being fixed by an assistant. A maximal flexion of the dislocated hip and knee in the sagittal plane follows (stage 1) Then the greater trochanter is placed correctly on the wedge, and abduction is cautiously increased to 90° in the frontal plane (stage 2) Here the greatest caution is necessary, a long lever arm should be carefully avoided and the thigh should be seized as shortly as possible, in order to avoid the danger of subtrochanteric or femoral neck fracture. Hurdling of the posterior rim of the socket (stage 3) occurs only when the thigh is forced down in back of the frontal plane. Palpation in the inguinal flexure yields information as to the deeper processes, and resistance offered by the cartilaginous lim-

bus will indicate the moment at which one may expect the femoral head to snap into the socket Reduction over the wedge is particularly difficult in cases near the limits of reducibility owing to the danger of fracture of the thigh One must never be tempted to make the reduction with sheer force at a first attempt. The force should be dosed and one must be prepared to interrupt the procedure lest its continuation cause inestimable harm to the patient.

Reduction over the *inferior rim* of the socket may be regarded as a variant of the Lorenz method It may often yield successful results because the inferior rim *of the socket is somewhat* more shallow than the posterior rim and because with forced flexion the anterior joint capsule is more relaxed thus apparently permitting a better opening of the capsular tube This method of reduction develops, so to speak, spontaneously, from reduction over *the posterior rim of the socket* since it only requires increased flexion to force the femoral head still further distally In this method too, it is difficult to dispense with the wedge The thigh is first flexed maximally, and with application of force in the longitudinal axis of the femur, the femoral head is forced downward as far as possible to the inferior rim of the socket With maximal flexion of the hip and knee joint the upward directed distal end of the femur is then moved in an outward directed curve until the distal end of the femur is in 90 abduction. The femoral head will then be below the inferior rim of the socket. If the thigh is then gradually placed in hyperextension the femoral head will approach the socket from *below* Here it may very easily happen that the prominence of *the femoral head is missing in inguine* and though the upward primary halt is insured the posterior halt is lacking, more careful investigation will then reveal that the femoral head lies *below* the site *of the* socket.

According to Haberler we have here to deal with an *infra acetabular pseudo reduction* which must not be confused with reduction to the site of the acetabulum Once recognized it is only necesary to reduce flexion somewhat and the *femoral head will snap into* the socket. If correct reduction has been achieved the leg must be brought back immediately into sharp flexion in

order to prevent redislocation upward The chance of a pseudo reduction at the inferior rim of the socket, or reduction to the obturator foramen, is the reason that reduction over the lower rim of the socket is not undertaken first in all cases

Fixation of the pelvis during reduction and during the lever maneuver is accomplished with little difficulty by the hands of an assistant exerting pressure over the pelvis against the substrate Mechanical apparatus of any kind for this purpose is completely superfluous. The hand remains always the best instrument. Whatever it can accomplish simply and surely, should never be relegated to the uncertain and complex working of a machine

Should all the above mentioned methods for overcoming obstacles to reduction fail, there remains no alternative but to interrupt the procedure, place the limb in bed traction and then, after an interval of about 14 days, to repeat the attempt. This is justified, of course, only when the findings do not seem to contraindicate further attempts at closed reduction and seem rather to favor one of the methods of open reduction which will be described later In young children under three years of age, skin traction is used, while in older children skeletal traction is employed The latter is attained with the aid of a Kirschner wire driven through the distal end of the femur A four-pound weight is attached to the stirrups and within a few days this weight is increased to 10 to 12 pounds Countertraction is obtained by means of a length of rolled linen slipped over the tuber of the ischium and fastened at the top end of the bed. The continuous traction of the weights unfolds the capsule and the soft parts are gradually stretched and their resistance overcome even before the actual reduction In cases with marked elevation of the trochanter which promises trouble from the beginning, the extension method is recommended as a *preliminary* procedure The child is then subjected to bed traction for fourteen days prior to operation. One will find that the relaxation of the muscles produced by this fourteen day weight extension will greatly facilitate reduction

2 RETENTION

Successful reduction constitutes only the first step of the treatment and must be followed by the equally important second step, namely retention The latter is for the purpose of stabilizing the extraordinarily labile reduction i.e., to retain or fix the reduced femoral head in its new position until the natural adaptive forces guarantee a permanent stability of the joint. Here too we may have to cope with certain difficulties. These are dependent (1) upon the inconsistency of the joint bodies, and (2) upon the laxity of the capsule which predisposes the joint to redislocation The primary object of retention is, therefore to maintain the *femoral head in that position in the socket which will afford the highest degree of stability*

a) *Primary Position* Since reduction is obtained in rectangular flexion and abduction this naturally constitutes the most suitable primary position In the moment of successful reduction, the position is maintained by tension of the shortened musculature No other maneuver neither traction nor pressure exerted against the trochanter is capable of so thoroughly insuring the femoral head against upward and posterior redislocation The primary position likewise insures the immensely important shrinking of the capsule at the lateral superior angle between the pelvic wall and the femur permitting a later diminution of abduction without danger of displacement of the head Furthermore the strain on the superior and posterior rim of the socket is relieved which constitutes an important factor in the further development of the socket

Thus the primary position *coincides in general with the position* assumed by the joint bodies at the moment of reduction and is generally speaking characterized by *rectangular flexion and abduction* If following successful reduction one departs the slightest degree from this position to approximate the indifferent extension position immediate redislocation will occur The classic primary position is, therefore not arbitrarily determined but a natural consequence of the prevailing anatomic and mechanical conditions. As for *rotation* it is abolished by the sagittal position of the axis of the knee joint in the primary position and is a natural result of the abduction due to rectangu

lar flexion Certainly rotation of the hip-joint in the new rectangular abduction position is in neutral equilibrium To influence the rotary position inward, the lower limb, rectangularly flexed at the knee joint, would have to be moved posterior to the frontal plane, whereas, for outward rotation, it must be moved *in front* of this plane.

The operator has, therefore, only to maintain and fix the primary position secured by reduction, namely, 90° flexion and 90° abduction More recent experience has taught us, however, that even this right angle position defined as the classic primary position will not satisfy all the criteria for a reliable retention, but requires a further exaggeration in order to sink the head deeper into the socket and to relieve the superior rim of the socket from any persistent pressure which may disturb the natural development of the acetabular roof This exaggeration of the primary position, which we have designated as *"accentuated primary position,"* is accomplished by exaggeration of its compon-

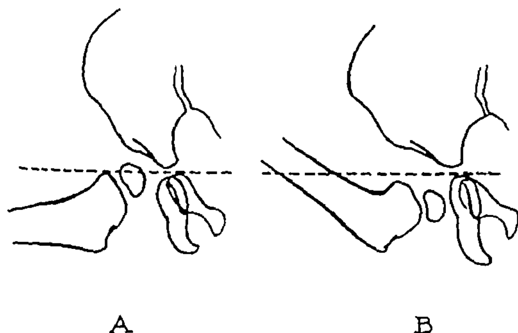


Fig 79 A "Classical" primary position i.e 90° flexion and 90° abduction the femoral epiphysis lies in the upper posterior quadrant of the acetabulum. B. *Accentuated* primary position i.e. 110 flexion and 90° abduction. In this manner femoral epiphysis lies below the Y line exactly opposite to the infundibulum (tracings from roentgenograms)

ents. As can be shown in the roentgenograms in the rectangular primary position the femoral head does not lie exactly opposite the acetabular fossa but in the *superior posterior quadrant of the* acetabulum If it is desired to place the femoral head exactly *concentrically*, then it would have to lie *beneath the Y-line* opposite to the infundibulum (Fig 79) In presence of simultaneous anteversion accentuation of the primary position offers the advantage of a deeper penetration of the femoral head into the socket whereas complete relaxation of the anterior iliofemoral ligament insures the same favorable chances for the shrinking The investigations of Brandes have furthermore shown that this not only guarantees a genuine reduction but that it may cause the femoral head, which lies below the limbus, to turn the latter outward

The flexion of 90 must therefore be increased to 110 125 The former designation of negative abduction" for this ultraphysiological degree of flexion is not wholly justified insomuch as in this position the thigh once more approximates the mid line, although remaining in the frontal plane so that there is only question of an increase in *flexion* Instead of the term negative abduction as defined earlier, it would be more correct to speak simply of hyperflexion A further increase in flexion above 125 , as recommended by Werndorff and referred to as axillary abduction we would consider too much exaggerated and uncalled for since it might result in lifting the femoral head out of the socket, thus counteracting the purpose of retention

If in the presence of a flat posterior rim of the socket the femoral head is easily displaced backward from the primary position we consider it advisable to increase also rectangular abduction a few degrees *we speak of this as hyperextension* In hyperextension one precaution must be observed owing to the danger of a forward dislocation of the femoral head due to hyperextension of the anterior capsule during the period of fixation We have then a pubic position as manifested by a striking rounded prominence in the inguinal furrow

The rule to be observed is as follows *Choose that primary position which upon testing stability after successful reduction*

is farthest from that femoral position in which redislocation occurs This will usually be found to be the *accentuated primary position of about 110°-125°*

The fact that the primary position just described is under the given conditions also most convenient for the child, since it permits at least a sitting position during the period of fixation is only mentioned incidentally because convenience is of course only a last consideration.

b) *Treatment of Bilateral Dislocation* In bilateral dislocation each of the involved joints will of course, in principle, require the same treatment as a unilateral dislocation The question as to whether it is better to treat the two joints simultaneously, or one after the other in two stages, has already been decided in favor of reduction of both sides in *one* sitting In addition to the far longer period of treatment required for the two-stage operation, there is also the disadvantage of having the two joints in different stages of treatment, and therefore in dissimilar conditions, so that a much longer period of time is required for the gait to attain the desired uniformity

The treatment of bilateral dislocation is in many ways fraught with greater difficulties than that of unilateral dislocation. To begin with the shortening in bilateral dislocation progresses more rapidly than in unilateral cases (p 109) For this reason, the difficulties of reduction presented by each joint separately in bilateral dislocation are greater than by the joint of a similar unilateral dislocation It is clear that only detailed individualization can lead to restitution in these initially less favorable cases.

Another impediment encountered in bilateral dislocation is the fact that completely symmetrical development of the deformity on the two sides is rarely present. Usually the joints differ both as to the degree of anteversion and shortening and often, too, in the type of luxation Frequently the one joint will present a complete dislocation whereas the other joint shows merely a subluxation (Fig 18) Thus it happens that the two joints will require not symmetrical but on the contrary very different adjustments, a requisite which will demand special attention

Once assured of the value of the primary position the problem remains of maintaining the hip in this position until it is stabilized there, so that redislocation would be unlikely even during later functional strain.

c) *Fixation in the Primary Position* This is accomplished by an acurately applied plaster-of-Paris cast, for the sole purpose of insuring the most advantageous primary position in each case Years of observation have taught us that only fixation in an *accentuated* primary position will offer insurance against redis location even though it cannot be denied that an anatomic restitution may be possible with less extreme positions. Experi ence has also taught us to maintain this position which we have determined to be the best *unchanged* during the entire period of fixation and with few exceptions, to permit neither diminu tion nor exaggeration thereof

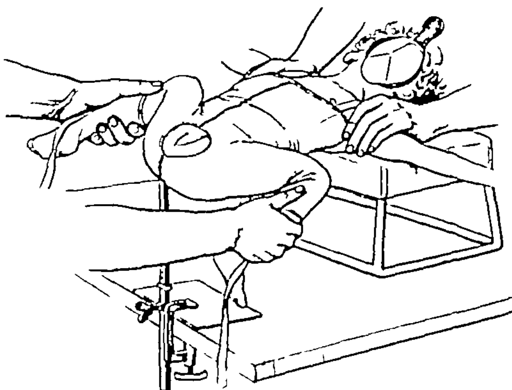


Fig 80 Bilateral dislocation of the hip following reduction in the primary position on a pelvic rest and bench with stockinette and scratch bands ready for plaster-of paris.

The bandage is applied on an ordinary operating table with the aid of a pelvic rest and a body bench. To begin with, hose of stockinette are pulled on the child. These must fit without a wrinkle and must cover the body as well as the knee. A muslin bandage, two inches wide, is introduced between the skin and the stockinette in front of the hip for use as a scratcher The child is then elevated on the pelvic support and bench A reliable maintenance of the primary position during application of the bandage is most important. One assistant holds both legs and the other pushes against the child's shoulders (Fig 80) Cotton pads are placed for protection over the most prominent bony points, the spines the sacrum and condyles of the knee. Generally speaking, however, padding should be reduced to a minimum. The layer of cotton is fastened by a muslin bandage and over this the actual plaster bandage is applied

It is advisable to apply the plaster turns according to a certain system, beginning at the pelvis and terminating just above the knee (Fig 81) The plaster turns are reinforced by correspond-

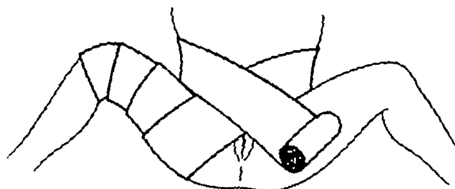


Fig 81 System of turns of bandages in bilateral dislocation.

ing plaster splints. In unilateral dislocation, the bandage is unilateral and extends to the level of the nipples. In bilateral luxation, a plaster-of Paris spica secures adequate fixation. *The knee and lower leg are left free on principle* (Fig 82) By leaving the knee free, enough motion is permitted to stimulate the development of the hip joint On the contrary the hip must be securely immobilized One of the most important requisites for successful retention is the exact fitting of the plaster bandage

With the application of the plaster cast, the period of fixation has begun The child is put to bed in a recumbent position over an inserted pillow For 24 hours the plaster is not covered so that it may dry thoroughly When the plaster has hardened the stockinette is then turned outward and sutured under tension over the plaster cast Of special importance are measures for preventing soiling of the cast by urine The popular covering of the plaster cast with oiled silk or other impermeable material *is not to be recommended* because this prevents evaporation of moisture, thus easily leading to decomposition of the cast. The

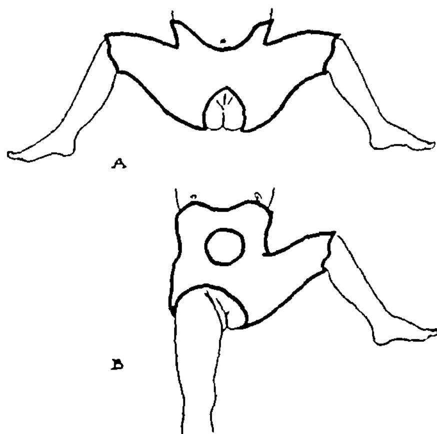


Fig 82 Plaster-of paris. *A In bilateral, B. In unilateral dislocation.*

best procedure is to insert diapers through the anterior and posterior pelvic portion of the cast The diapers are turned over the cast, fastened with safety pins and changed after each soiling

The patients are permitted out of bed after two to three days. They are furnished with a special chair in which they can

sit comfortably (Fig 83) The children are encouraged to move their knees during the entire period of fixation

d) *Duration of the Period of Fixation* This is determined by two developments To begin with, the reduced joint must

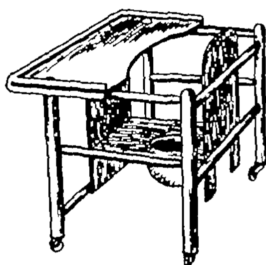


Fig 83 Chair for use during period of fixation.

have attained a shape which will insure maintenance of retention On the other hand the time limit allowed must not be extended to a point where contracture or ankylosis may vitiate operative results This last mentioned danger is imminent especially in older children It should be emphasized, however, that a joint, the primary position of which can be directly diminished without the use of force, is not yet ready for removal of the cast. The ability to distinguish between the degree of rigidity desired, and that which may prove injurious, can only be gained by years of experience.

Lorenz originally recommended a relatively short period of fixation of three to six months, but as the dangers of redislocation became manifest, this period was prolonged *In my opinion, for children under three years of age, nine months is the shortest time in which a dependable acetabulum can be expected* In many instances, a whole year may be necessary The roentgenogram will determine the decision. If the roentgenogram shows a good bony formal development of the acetabulum, which should surround at least half of the femoral head, the development may

be regarded as satisfactory Otherwise removal of the cast i be still further postponed. The warning against "quick et cannot be too strongly emphasized In general the rule ap that it is *better to prolong the period of fixation, risking even complications which will require corresponding after treatm than to interrupt the period of fixation and risk a redislocati*

As regards the number of casts, repeated change of pl should be avoided as far as possible, not only because it is desi to spare the child unnecessary "handling but primarily to c ate eventual displacements of the joint position during ch of casts Since a cast under proper care remains in good cond for four, or even five months, only *two* or *three* casts, and th fore, at most, *one* or *two* changes will be necessary

If the cast has to be changed, the greatest care is necessar avoid displacing the joint. Any radical change in the positio the leg disrupts the rebuilding process. For this reason we sa ourselves with a single uniform position of fixation This sim fies the procedure considerably, and repudiates the term 'tor treatment ' applied by the laity not wholly without justificat After removal of the first cast the skin is cleansed, a roentge gram is taken for purposes of control and whenever poss the second cast is then immediately applied in the same posi as before The application of the second cast is, of course, alw undertaken *without narcosis*

Changes in *position* are indicated only if a displacemen the original basic position has occurred within the cast as ne occasionally in obese children with very shallow sockets, or ow to saturated softened casts. The change occurs chiefly as a sl accentuation of the original position, therefore as increased f ion and abduction It is only in cases with a tendency to ante redislocation due to forced hyperextension that hyperexten may be diminished the accentuated flexion being howe maintained

3 AFTER TREATMENT

The object of after treatment following removal of cast is to obtain in the most harmless manner a transition fr the primary to a neutral position completely free from ste

While fixation according to our method is very simple, the after-treatment is no less so. Restoration of the parallel position of the legs is relegated entirely to *spontaneous correction* with avoidance of any passive manipulations whatsoever.

In mentioning this restoration of the parallel position of the limbs first, we do not mean to imply that this is the first urgent aim of after-treatment. On the contrary, for shaping the reduced joint so as to give an adequate acetabular roof, it is more important that a slight degree of abduction be maintained as long as possible. The longer abduction is maintained, the more stable the joint will become. No attempt should be made to expedite the attainment of the parallel position. Fear of contracture or ankylosis of the joint after protracted primary position in younger children is not justified. I have never encountered a single case within the 5 to 6 year age limit in which the legs could not be brought down into parallelism. The transition to a normal position should be left entirely to the child's urge to move about. Our efforts during the after-treatment period are in fact directed toward bringing the limb constantly back into the primary position. This purpose is served by a posterior shell.

Preparation of the posterior shell: the child is placed in ventral position, the hip in the same position as formerly in the plaster cast. A double layer of sheet wadding is applied over the pelvis and thigh. Over this sheet wadding a layer of muslin is applied and a cast of corresponding thickness is formed by plaster splints running from the pelvis to the thigh. The last bandage is applied as a roller bandage. After the cast has hardened, it is lifted from the body and dried. It is a great help to cover the cast with bandage cushions and some material. To prevent the child from falling out of the cast, the latter is fastened in front with straps (Fig. 84).

Recently we have employed, instead of the posterior shell, the earlier described abduction bar (p. 157), which served so well for prophylactic purposes, and can recommend it also for after-treatment as being more comfortable and easily kept clean.

The cast and abduction bar are used for six months during the *night* only. In the day time, the child is left completely f



Fig 84 Posterior shell for after treatment in bilateral dislocation of the hip used only during the night.

but the nurse must be instructed to carry the child and to let it be seated always in the same spread position as maintained in the cast

Whereas on one hand therefore it is the aim of after treatment to facilitate the ability to reproduce the primary position, on the other hand the possibility of being able to reproduce the primary position without difficulty at any time constitutes an exact test of the stability of the reduction

Before proceeding to discuss the other measures to be taken during the period of after treatment we must devote a moment to the problem of functional weight bearing Lorenz is well known to have attached great importance to this aspect since he attributed to it a marked influence upon the further formation of the joint Nevertheless we believe it better to *avoid any*

weight-bearing of the joint while in the cast, and for the first months of the after-treatment period, because, in the presence of incomplete stability of shape, weight-bearing might involve dislocating components following diminished flexion and abduction. For this reason, we recommend that during the period of after-treatment, one should be guided only by the absolute guarantee against redislocation and not by any regard for functional stress.

Instead of "functional weight-bearing" which owing to the marked abduction remains illusory, a "*functional training*" by muscle action is begun in part even during the period of fixation. This includes active and passive gymnastics of the knee joints, which are free, and is designed to strengthen also the muscles dominating the hip-joint. After removal of the cast, also the hip-joint is exercised actively and passively, but only in the direction of increased or diminished flexion. The 90° abduction should be maintained. The exercises are supplemented by massage of the gluteal and femoral muscles. In the beginning, the gluteal muscles are entirely lacking in power. Later on resistance exercises may be included, the leg being held back by the hands on the ankles. In any case, after-treatment is so simple that it can easily be attended to at home by the person in charge.

Nevertheless, it takes some time before the little patient feels enough strength in his legs to attempt supporting himself on them. However, even timid children, or those with bilateral reductions, usually make their first attempts at walking a few weeks after removal of the cast. F. Schede recommends for walking exercises the use of his "Laufrad" (a tricycle without peddles) which is, however, suited only for older children. As a rule, one must count on a period of about six months for complete straightening of the legs and a normal gait. *No weight-bearing is permitted unless an adequate hip joint can be demonstrated roentgenographically.*

Roentgenographic films should be taken at intervals as frequently as every three months so that careful observation may be made of the bone regeneration which will produce a good joint.

In exceptional cases modification of the after treatment may be necessary *Outward rotation* requires special attention. It usually makes its first appearance, when flexion has been diminished in order to promote parallel position of the legs. Lorenz has drawn special attention to this change in the situation On rectangular flexion and abduction, the transverse axis of the knee-joint is sagittal. As long as the axis of the knee joint remains in the sagittal position, outward rotation as already mentioned, is an attribute of *abduction from rectangular flexion* (p 178) The moment that flexion is diminished however the sagittal position of the transverse axis of the knee joint signifies outward rotation which upon full extension amounts to 90°, at which the foot will be pointing directly outward

Outward rotation is usually spontaneously compensated in time, by the natural inward position during walking In stubborn cases, the outward rotation may be influenced by active and passive movements of inward rotation In these cases we have found the Ponseti modification of the *Denis Brown splint*, with a long bar between the two feet, of special value It affords the possibility of a gradual diminution of abduction and outward rotation The Denis Brown splint should be used for six weeks.

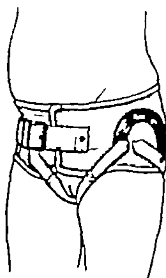


Fig 81 Dislocation girdle with trochanter band for after treatment in cases of deficient development of the acetabulum.

Children with a deficient development of the acetabulum are also given a *dislocation girdle*, to preserve the relation between the femoral head and socket (Fig 85) It consists of a strap six inches wide, with a laterally attached trochanter stirrup, which presses against the trochanter by means of thigh straps.

The treatment of eventual contractures is of great importance. As mentioned earlier (p 165) in older children, a *flexion contracture* of the *knee-joint* may even develop immediately after reduction in response to stretching of the hip flexors In order to prevent this contracture, it is necessary that stretching exercises of the knee-joint be instituted shortly after reduction, and be repeated several times daily during the period of fixation.

Much more frequently encountered complications during the period of after treatment are *contractures of the hip-joint* Persisting contractures will require attention since otherwise permanent shrinking of the capsule or even rigid ankylosis of the joint may ensue.

Abduction contracture may present very marked difficulties, when, in children with bilateral dislocations, the transition to a parallel position of the legs is unequal on the two sides i e., one hip being already fairly straight spontaneously, while the other still remains in rigid abduction If the abduction on this side is permitted to continue, under the influence of weight-bearing, the other side may go into a compensatory *adduction*, and thus force the femoral head out of the socket on this side. In such cases, the equilibrium must be restored as soon as possible by diminishing abduction of the *one* limb, at the same time placing the *other* adducted limb into exaggerated abduction This correction must be accomplished with extreme caution, excessive adduction of the abducted limb may lead to redislocation After correction has been achieved a plaster cast is applied which should also include the trunk and in order to prevent undesirable rotations, is extended also to the toes. This cast is left in situ for four weeks.

Flexion contracture of the hip joint during the period of after-treatment is usually due to the ultraphysiological abduction of the primary position. In older children, under the strain of weight bearing in the presence of a diminished resistance of the

atrophied capsule, this may lead to posterior dislocation Flexion contracture is best combatted by application of sand bags. The child is placed in ventral position and the knees are rotated inward For one-half hour daily, sand bags weighing from five to ten pounds, are placed over the pelvis (Fig 86) In very resistant

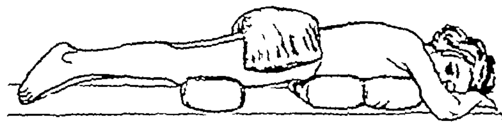


Fig 86 Sandbag weights to combat flexion contracture of the hip during after treatment

cases, a subcutaneous tenotomy of the sub spinal muscles (tensor fasciae latae, sartorium and rectus) may be performed under general anesthesia.

The principles of the treatment may, therefore be summarized as follows

1 *Reduction is achieved over the posterior rim of the socket by a carefully dosed manipulation*

2 *Fixation is made in an accentuated primary position which is maintained unchanged throughout the entire duration of the period of fixation*

3 *The duration of the period of fixation ranges according to the age of the patient and the severity of the case, from nine months to one year, with a maximum of one to two changes of cast*

4 *Corrections of position during the period of fixation are permissible only when the femoral head has become displaced in the cast i.e in the presence of a tendency to upward and posterior dislocation by an exaggeration of flexion and abduction components or on a tendency to forward dislocation by a diminution of the abduction components of the primary position*

B OTHER METHODS

Attempts to modify the Lorenz method by perfecting certain details or to replace it completely by changing its essential features have not been wanting

Among the older methods, especially that of F Lange is deserving of serious consideration According to Lange reduction is accomplished by traction the limb being extended at the knee, and the hip simultaneously rotated inward and abducted 140 in the frontal plane The femoral head is then reduced into the acetabulum over the *upper posterior rim* of the socket by direct pressure on the trochanter For this purpose, Lange makes use of a traction apparatus and a lever bar, by aid of which the femoral head is forced into the socket Following accomplished reduction the limb with extended knee and full extension of the hip is immobilized in a plaster cast in *140° of abduction and marked inward rotation* The first cast is left in situ for three to five months the second in diminished abduction of 20°, but otherwise applied like the first, is left on for two to three months. Whereas the child may not walk in the first cast walking is permitted in the second cast Lange believes that the advantage of his method lies in the fact that with traction and the lever bar greater force can be used, rendering this method of reduction possible in cases, in which the lever maneuver of Lorenz fails. Furthermore, the inward rotation considerably favors shrinking of the superior anterior parts of the capsule, thus helping to prevent the anterior and upward redislocation so often experienced in anteversion.

As has been repeatedly emphasized the Lange method offers not the slightest advantages over the Lorenz method. It neither prevents anterior redislocation, since the anterior capsule gives way, being incapable of resistance, nor does inward rotation present an effective agent for correction of anteversion In our opinion the anteversion is only concealed by the inward rotation position and recurs once this position is surrendered Since the wall of the acetabulum is harder and more resistant than the femoral head there is indeed a possibility that anteversion may even be increased by pressure of the head against the socket

One of the chief objections to Lange's method is that it offers considerably less primary stability than that offered by the primary position of Lorenz Above all one has to reckon with the danger of a *posterior redislocation*, as can easily be demonstrated by attempting dislocation following reduction This danger was

not ignored by Lange In the presence of a tendency to posterior redislocation he immobilized the limb in a plaster cast for ten days in the Lorenz primary position in order to achieve a shrinking of the posterior capsule, and then proceeded to the described inward rotation in a second fixation Just how little confidence the real originator of inward rotation (Schede) had in this position as a means of correcting anteversion, is apparent from the fact that he and his followers regarded it merely as a preliminary preparation for eventual detorsion osteotomy Even Le Damany, one of the most eager advocates of early correction of anteversion nevertheless found it necessary to maintain the primary Lorenz position for three months, and then to proceed with mechanical measures for correction of anteversion

Another very important objection to the inward rotation position is, furthermore, the fact that we have observed it in numerous cases to be the cause of most severe postoperative changes in the femoral head Changes of such degree are observed only rarely following the Lorenz method, and can be explained as being due to the prolonged pressure of the weak epiphysis of the femoral head against the posterior wall of the socket *We believe that we can better guard against anterior superior and posterior redislocation by using our accentuated primary position which permits a deeper penetration of the femoral head into the socket than can be accomplished by inward rotation*

Otherwise our objections to the inward rotation position pertain only to its use as a primary position in early infancy As a secondary position we too make use of it occasionally in older cases to prevent a threatening flexion abduction contracture of the hip

Apparatus similar to that of Lange for *instrumental* reduction have been constructed by Bradford Menciere Gocht and others. The most important feature of these is the utilization of traction and the use of a metal rod acting as a single armed lever Reduction is then, of course accomplished over the upper rim of the socket and is for that re[illegible]idered chiefly for cases of subluxatio[illegible]ior ante[illegible]ation

It cannot be gainsaid that these instrumental reduction apparatuses facilitate reduction in the more difficult cases But we are of the opinion that reduction can be accomplished much better and more certainly by hand. Moreover, with the use of lever machines, the invaluable direct contact with the object is sacrificed The manual method also clearly demonstrates the phenomenon of reduction and permits an immediate evaluation of the result of reduction

Several writers (Schanz-Weischer, Horvath) recommend a modified reduction over the *posterior inferior margin* of the socket. This is accomplished with the thigh flexed and adducted the operator on the opposite side exerting a sudden violent pull in the given direction of the thigh, which is then brought into right angled abduction The advantage here is a less marked stretching of the anterior capsule.

Hibbs and Blankart describe methods of reduction over the *inferior margin* of the socket which differ little in technic from the methods previously mentioned

Bradford has extended the possibilities of further modifications in reduction by the idea of accomplishing the typical reduction free-handed over the posterior margin of the socket, with the child in *ventral position* The child is placed face downward over the edge of the table in such a manner that the luxated limb hangs down The operator places one hand on the trochanter, and with the other he grasps the knee of the pendulous limb He can then easily exert the desired flexion abduction and rotation

Other methods frequently employed here are those of Hibbs, Ridlon and Denucé.

Hibbs' Method The child is placed upon a table to which it is fastened by pelvic straps The leg on the affected side is then flexed on the abdomen The leg is then extended, with the thigh held in abduction and flexion A trochanteric pad is then pushed up by a screw directing the head upward and forward Following this, the thigh is abducted, thus forcing the head to travel upward anteriorly into the acetabulum

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Otherwise our objections to the inward rotation position pertain only to its use as a primary position in early *infancy*. As a secondary position we too make use of it occasionally in older cases to prevent a threatening flexion abduction contracture of the hip.

Apparatus similar to that of Lange for *instrumental* reduction have been constructed by Bradford, Menciere, Gocht and others. The most important feature of these is the utilization of traction and the use of a metal rod acting as a single armed lever. Reduction is then of course accomplished over the upper rim of the socket and is for that reason considered chiefly for cases of subluxation and superior anterior dislocation.

It cannot be gainsaid that these instrumental reduction apparatuses facilitate reduction in the more difficult cases. But we are of the opinion that reduction can be accomplished much better and more certainly by hand Moreover with the use of lever machines, the invaluable direct contact with the object is sacrificed The manual method also clearly demonstrates the phenomenon of reduction and permits an immediate evaluation of the result of reduction.

Several writers (Schanz-Weischer, Horvath) recommend a modified reduction over the *posterior inferior margin* of the socket. This is accomplished with the thigh flexed and adducted, the operator on the opposite side exerting a sudden violent pull in the given direction of the thigh which is then brought into right angled abduction The advantage here is a less marked stretching of the anterior capsule.

Hibbs and Blankart describe methods of reduction over the *inferior margin* of the socket, which differ little in technic from the methods previously mentioned

Bradford has extended the possibilities of further modifications in reduction by the idea of accomplishing the typical reduction free-handed over the posterior margin of the socket, with the child in *ventral position* The child is placed face downward over the edge of the table in such a manner that the luxated limb hangs down The operator places one hand on the trochanter and with the other he grasps the knee of the pendulous limb He can then easily exert the desired flexion abduction and rotation

Other methods frequently employed here are those of Hibbs, Ridlon and Denucé.

Hibbs' Method The child is placed upon a table to which it is fastened by pelvic straps. The leg on the affected side is then flexed on the abdomen. The leg is then extended with the thigh held in abduction and flexion A trochanteric pad is then pushed up by a screw directing the head upward and forward Following this, the thigh is abducted thus forcing the head to travel upward anteriorly into the acetabulum.

not ignored by Lange In the presence of a tendency to posterior redislocation he immobilized the limb in a plaster cast for ten days in the Lorenz primary position in order to achieve a shrinking of the posterior capsule, and then proceeded to the described inward rotation in a second fixation. Just how little confidence the real originator of inward rotation (Schede) had in this position as a means of correcting anteversion is apparent from the fact that he and his followers regarded it merely as a preliminary preparation for eventual detorsion osteotomy Even Le Damany one of the most eager advocates of early correction of anteversion nevertheless found it necessary to maintain the primary Lorenz position for three months, and then to proceed with mechanical measures for correction of anteversion

Another very important objection to the inward rotation position is, furthermore, the fact that we have observed it in numerous cases to be the cause of most severe postoperative changes in the femoral head Changes of such degree are observed only rarely following the Lorenz method and can be explained as being due to the prolonged pressure of the weak epiphysis of the femoral head against the posterior wall of the socket *We believe that we can better guard against anterior superior and posterior redislocation by using our accentuated primary position which permits a deeper penetration of the femoral head into the socket than can be accomplished by inward rotation*

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Ridlon's Method The patient's hips are elevated about four inches on a sand bag An assistant holds down the pelvis and thigh on the other side If the left hip is dislocated the operator's left hand is placed in the patient's crotch with the thumb in front of the socket and the first second and third fingers on the femoral head neck and greater trochanter of the dislocated hip The bent knee is held in the palm of the operator's right hand *The thigh is then flexed until the head reaches the lower* border of the socket Thereafter the thigh is abducted and passes into the socket The thigh is in 90 flexion 90 abduction and rotated outward 45° In this position, the plaster cast is put on and carried below the flexed knee These cases are all kept in a plaster cast for eight months or more

Denuce's Method The reduction is preceded by manual stretching of the adductor muscles, which is accomplished by stroking them downward with the palm of the operator's hand The thigh is then brought up to right angle flexion with the knee carried across in the direction of the opposite axilla and the thigh firmly pressed down on the anterior body wall With the extremity held in this position with one hand, the other hand is placed under and around the head neck and trochanter Circumduction is then begun the knee being carried to its own side and into abduction while the trochanter is lifted upward until the head is felt to come forward and lodge in the acetabulum A plaster cast is applied with the thigh in 90 flexion and abduction the knee included At the end of three months the cast is bivalved the front half discarded and the child receives massage and is exposed to sunlight

Other insignificant modifications of the classical method have been introduced by Waldenstroem Gaugele and Kienzle Schede and others.

The question now arises as to which of this large number of methods of reduction is best With respect to the chief aim of treatment it is as a rule fairly indifferent which method of reduction is used whether the latter be over the superior posterior or or inferior rim of the socket In difficult cases when one method fails another may be tried In general however we believe that the Lorenz method of closed reduction has attained

such a degree of perfection, that little is to be expected from possible modifications. Instead of a constant attempt to invent new modifications, which differ only insubstantially from the original method, we believe it would be much more profitable to study this method more thoroughly and to apply it more accurately in all details.

The original and important feature of the Lorenz treatment is the autochtonous classic primary position during the retention period But even this aspect has been criticized by a group of opponents

Attention has already been directed to Lange's method Another modification of the usual primary position was originated by Calot. The Calot position differs only slightly in principle from the primary position of Lorenz. The recommended abduction of 70° to 80° constitutes only a diminished classic primary position presenting the disadvantage of a greater lability of the joint We can only agree with Drehmann who warns against the use of such intermediate primary positions. Menciére has justly objected that the Calot position favors redislocation and that the diminution in abduction and primary inward rotation must be regarded as exceptional.

Compromising between these two suggestions, Campbell maintains the Lorenz position for a period of three months, after which the degree of abduction is reduced, the hip rotated inward, and fixation is then continued for an additional four months.

On the other hand we are definitely opposed to the innovation approved by numerous writers (Schede, Petersen, Vogel, Reeves and others), namely, that of combining a fixation cast and continuous traction apparatus This dooms the child to a wholly unnecessary prolonged bed rest, and what is worse, this procedure interferes with the functional stimulus so necessary for the further development of the hip joint.

Strangely enough Hilgenreiner, to whom we are indebted for such valuable advice for early diagnosis and early treatment, has recently suggested the use of his abduction splint instead of a plaster cast following reduction, not only as a prophylactic measure in infants but also for older children It is difficult to understand just what advantages could accrue from this method

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since Hilgenreiner fixes his splint throughout *the entire period* of treatment with an unremovable crinoline bandage, including the trunk and both thighs just as it is fixed in a plaster cast As regards the functional weight bearing *he speaks of, we would* draw attention to the fact that this originally constituted the basic principle of the Lorenz treatment, so that even in this respect the suggestion cannot be considered as any forward step

Moreover, splints and apparatus had been tried in an attempt to dispense with or shorten the plaster cast treatment even before Hilgenreiner (Le Damany, Gaugele, Hoeftmann, Roederer Joachimsthal, Peltesohn Elsner Schede, Kafka and others) but were always subsequently discarded because of their unreliable effects.

C. AGE LIMITS

The next question that arises is that of the best time for beginning treatment. Lorenz recommended that reduction should not be attempted before the infant has become continent since treatment with continuous casts is very difficult unless absolute cleanliness can be maintained. Accordingly he believed reduction should be done at the earliest in the middle of the *second year, or better still at the completion of the second year* of life The favorable primary stability frequently present at this age period, seems to indicate that the acetabulum continues to develop at this stage owing to its natural growth energy Also the statistics of many surgeons show the highest percentage of perfectly maintained cures up to the end of the third year of life

In contradiction to this opinion, most writers of today believe that treatment should be initiated as early as feasible, and if possible soon after birth Putti's line of reasoning cannot be improved upon and I wish to quote from his paper "It is a fundamental principle of orthopedics that congenital deformities should be treated from moment of birth Why on earth should not the principle which for example is so rigorously applied in the treatment of clubfoot and which with more laxity is adopted in the treatment of wry neck cleft palate and scoliosis why should not this hold good also for that of congenital

dislocation of the hip? Undoubtedly the early treatment offers the greatest possibility for progress in the treatment of C D H It has also been advocated by Hilgenreiner, Bauer, Fairbank, Spitzy, Schede, Severin and others

We are in thorough agreement with this modern conception and in accord with Putti, Hilgenreiner and others construe the early treatment of C D H to mean treatment in the *first* year of life

Naturally, children with congenital dysplasia even with a tendency to luxation, require *no* reduction in the first year of life. In these cases, as we have seen simple prophylactic measures will, as a rule, suffice (p 155) However, in cases of beginning subluxation or luxation, or, in cases where such prophylactic measures have failed, reduction should be undertaken immediately Only in very exceptional instances will it be necessary to postpone reduction, owing to an unfavorable condition of the general health or nutritional disturbances

Several arguments can be offered in favor of early treatment to begin with, reduction is easier, the younger the child. The shortening is still slight, the acetabulum not yet filled with cellular tissue and the congruity of the joint bodies has not yet been disturbed. Furthermore, it has to be taken into consideration that the whole treatment is less irksome to a younger child, who tolerates prolonged immobilization better when he has not yet learned to walk But primarily, it is an established fact that *results are far better, the earlier treatment is begun* Doubtless the reactivity of the basic substance is greater in the younger child, and for this reason, the chances of regeneration are much better than in an older child

The determination of the *upper age limit* is most important. In view of the great interest displayed currently in applying early treatment, the upper age limit would seem less liable to be exceeded. Nevertheless some stragglers are always to be encountered. It has been our experience that the *upper limit for closed reduction of unilateral dislocation is at the completion of the sixth year, and for the treatment of bilateral dislocation is at the completion of the fifth year of life* The difference between unilateral and bilateral dislocation consists in the fact that the

primary inhibition of growth responsible for the congenital dislocation is present to a much more marked degree in bilateral than in unilateral dislocation It must also be kept in mind that the shortening in bilateral cases increases more rapidly than in the unilateral cases (p 120)

Of course, this arbitrary determination of the upper age limit has only a general significance. In individual cases, unresistant soft parts, a loose condition of the articular ligaments, delicate bone structure of the patient, or other individual factors may displace the age limit upward, whereas opposite conditions in another case may bring the age limit farther down

D ACCIDENTS AND COMPLICATIONS

Reduction also involves certain risks which may be dependent upon the maneuver of reduction Here one has to consider fractures lesions of the soft parts, and nerve injuries, and finally, also spasmodic conditions due to sudden tension All of these complications are observed almost exclusively in *older* patients, who are more or less beyond the age limit.

Among the possible accidents, *fractures* occupy first place Most frequently, these consist of fractures of the neck of the femur or subtrochanteric fractures. Often there may be epiphyseal detachments in which case the roentgenogram will not infrequently show considerable displacement of the epiphysis. The severe trauma of reduction in older children may also, of course, give rise to blood effusions, lacerations of the capsule contusion of the periosteum, or injuries to the articular cartilage with subsequent partial necrosis. With improving technic and a better conception of the optimum age limits such injuries are now rare however Whereas in 1907, Lorenz and Reiner reported 13 fractures in a series of 450 cases, we experienced only seven fractures in our series of 2,138 cases in the last 20 years. Fractures inflicted on the operating table are always most deplorable since they render immediate treatment of the fracture necessary thus involving an unfortunate prolongation of the treatment With proper care, however no serious consequences to the patient need be feared

In order to avoid fractures it is important that during reduction the thigh should be grasped as close to the joint as possible

and that upon actual contact with resistance, the force exerted should not exceed the normal limits of elasticity of the bone If the resistance of the soft parts does not yield and the bone bends under the pressure of the hand, the maneuver must be discontinued and other measures be resorted to

If a fracture has occurred, it must be allowed to heal, and the attempt at reduction may then be repeated after two or three months. However, the danger of a repeated fracture is considerably increased owing to the bone atrophy which has developed in the meantime, and for this reason even greater care is necessary than at the first attempt at reduction In diaphyseal fractures of the thigh in the presence of anteversion, one may convert the misfortune into an advantage, accomplishing detorsion by outward rotation and thus correcting the anteversion On one occasion Lorenz following a subtrochanteric fracture, displaced the upper end of the distal fragment into the acetabulum, thus furthering his original plan of supporting the pelvis at the site of the acetabulum in irreducible dislocation, by a subtrochanteric osteotomy

Another serious complication requiring discussion is that of *reduction paralysis* This is encountered only in older cases and following protracted forced reduction maneuvers. We have in such instances to deal with pareses or paralyses in the region of the sciatic and femoral nerves Lorenz reported 23 instances of paralysis of the sciatic nerve in his series of 767 cases. In our series of 2,138 patients, we experienced only five cases of sciatic paralysis. According to Froehlich, nerve involvements occur nearly always in children between the ages of five and nine years, and in cases in which the original shortening was more than 5 cm.

Delitala has contributed statistics revealing most interesting data. In a series of 1,071 reductions, he found paralyses in 1 6 per cent of the cases. In three of these cases there was total paralysis of the legs, in two cases involving the sciatic nerve, in eight cases the crural nerve, and in five cases the peroneal nerve Most of these patients were between the ages of 15 and 20 years. Only three were under five years of age

Paralysis in the distribution of the femoral nerve may be recognized by paralysis of the quadriceps and is usually caused by forced hyperextension This is of a benign nature and usually subsides without treatment within a few weeks. *Of much* more serious import are the paralyses of the sciatic nerve caused by hyperextension of the nerve during too sudden a correction of marked shortenings, or by compression of the nerve between the femoral head and pelvic wall during the reduction maneuver which unless quickly released may lead to irreparable damage. Paralysis of the sciatic nerve is immediately manifest by deficiency symptoms in the peroneal region (absence of dorsal flexion of the foot)

Fortunately, cases in which paralysis becomes permanent are rare Narath describes a case with residual bilateral paralysis of the extensor digitorum and paresis of the joint musculature In a case reported by Petersen, paralysis of the peroneal muscles persisted for two years. In a case which I observed personally, in a girl of seven years, with a bilateral dislocation of the hip there developed a total sciatic paralysis of one side This condition subsided completely after a period of five to six months.

The most important and strictest requirement is that of ascertaining immediately when the child awakens from the anestetic, by a pin prick into the sole of the foot, whether extension of the toes or foot joints has been affected or not If there are signs of paralysis, the cast must be removed at once and the head redislocated bringing it to its original dislocated position in order to release the nerve. To maintain reduction if even for a single day once paralysis has been demonstrated is disastrous, and must be regarded as a grave error in technic. Other measures for the treatment of paralysis include massage and electrotherapy *To prevent drop foot* a posterior splint with the foot at a right angle may be applied

Other serious complications following closed reduction have been reported by Stephens, among others, *rupture of the femoral artery* in a girl of twelve years following a second attempt at closed reduction

Spasmodic contractions during the first few days and nights following reduction may be attributed to extreme muscular ten

sion. Occasionally also severe shock reactions have been observed In his first 360 cases, Lorenz reported three deaths occurring immediately after reduction with symptoms resembling shock There was no mortality in our series of cases. In cases of threatening spasmodic attacks or shock, the cast should be removed immediately, and the hip should be redislocated to relieve tension

Another condition, which may be considered as a complication, is the occasionally observed *hematoma* appearing in the groin, which are frequently associated with extensive edema of the labia or scrotum. Hematoma and edema will usually subside within a few days following application of moist compresses We have encountered suppuration of a hematoma in only a single case.

It must, in all justice, be admitted that all of these accidents cannot be charged to the method per se, but are attributable solely to the fact that its sphere of usefulness has been exceeded in applying it to children who are far too old for closed reduction.

For this reason, it is *earnestly recommended that trespassing beyond the accepted age limits be avoided, and that forcible reduction be omitted even in difficult cases within the age limits*

E. TREATMENT IN OLDER PATIENTS

We have emphasized the fact that closed methods of treatment of C D H are indicated only within a certain age limit. The latter is usually low, being placed for unilateral dislocation at completion of the sixth year, and for bilateral dislocation at completion of the fifth year (p 198) Beyond these age limits the difficulties of treatment rapidly increase, and may as the patient grows older even become insurmountable Even reduction meets with serious resistance owing to nutritional shortening of the muscle, hour-glass contraction of the capsule, or adhesions of the capsular hood and pocket. Eventual failure is attributable to deficient development of the socket In the older age period, the acetabulum ceases to grow and becomes incapable of further development. On the other hand, we have the striking phenomenon that in some instances, in spite of the

absence of the femoral head in the socket, the acetabulum may continue to develop due to a residual power of growth and show a greater susceptibility in later years than during the earlier years It is easy to see therefore why attempts have been made to extend the period for treatment considerably beyond the accepted time limit. Thus Stumme Bade, Drehmann Lorenz, Reiner, Springer Gourdon, Bradford and others have reported successful reductions in patients up to fifteen years of age and over

In general however exaggerations in this direction should be avoided The price of recklessness in this connection is only too frequently accidents of all kinds. However under especially favorable conditions, reduction may be accomplished with surprising ease also in older cases. Successful reduction may be possible in such cases when there is only a slight shortening not exceeding 1 to 2 inches, or in the presence of particularly favorable form relations between the femoral head and socket or in cases in which roentgenograms show that the femoral head on longitudinal traction can easily be brought down near the level of the socket (telescopic test)

To be sure, it is neither possible nor advisable in these cases, to undertake treatment in the same manner as described in the preceding chapter Such children must first be subjected to a *preparatory* treatment such as traction in bed *Skeletal traction* by means of a Kirschner wire is employed The patient is then *placed on a Braun splint* with a weight traction of 10 to 20 pounds. The foot of the bed must be raised about 20 inches. Most probably *the continuous traction not only stretches the* musculature but may also gradually widen the isthmus, and thus facilitates passage of the head during reduction

Traction should be maintained until the femoral head has been pulled down to the level of the socket and all tension has been overcome In mobile hips, this procedure will take two to three weeks in more rigid hips four weeks. The effect of the traction is controlled by bedside roentgenography We consider tenotomy of the abductors unnecessary and unsuitable because with this procedure the lever effect which is so impor

tant for reduction, is lost In some cases, however the adductor tendons should be divided subcutaneously before attempting any reduction

If after such preliminary preparation, the femoral head can be drawn down to the level of the socket, one may proceed to reduction. Success will depend upon the presence of a susceptible acetabulum. No force should be applied at this sitting If reduction by this method fails, it should be given up for the time being, and operative or palliative measures attempted

If reduction is successful, one has nevertheless to reckon with a greater tendency to contractures than is observed in younger children. The soft parts shrink much more rapidly in the older children because of a greater state of tension. In order to avoid this, fixation in the primary position should be maintained for only three months at the most We assume that after this time, shrinking of the capsule has progressed to such an extent that it will prevent redislocation Thereupon in a second sitting, with the utmost caution not to displace the hip, we proceed to change the primary position into the Lange position (40° abduction and marked inward rotation) It is fixed in this position for the next six weeks. Following removal of the cast, mobilization of the joint by suitable joint exercises should be instituted as soon as possible. The patient is not allowed up until six months have elapsed.

It is advisable to fix the limb in the Lange position immediately after reduction only in cases with marked anteversion up to 90° anticipating a detorsion osteotomy six weeks later

In this manner it has been possible for the author to obtain reduction in a few selected cases of bilateral dislocation in patients up to eight years and in unilateral cases up to ten years of age without any complications. Such cases will however, always constitute the exceptions. In dislocations after the tenth year *no* attempts at reduction are justifiable

F ANATOMY OF THE REDUCED HIP JOINT

Some writers have had the opportunity of performing autopsies on children dying of intercurrent disease at various periods following reduction

Allison (1905) was one of the first who studied the anatomic conditions following closed reduction in a case of double congenital dislocation in a girl of seven years, who died four months after manipulative reduction, of tuberculous meningitis. The reduction had been very difficult, but was accomplished in a satisfactory manner by the Lorenz technic. Allison describes the findings as follows During the section evidences of an old hemorrhage and lacerations were discovered, particularly in the adductor muscles. The capsule was abundant and much thickened posteriorly The lig teres was abnormally long The socket was shallow of triangular shape with the base posterior The cartilage was present, i e, covered with connective tissue. For the rest, Allison confines his report chiefly to anatomical data and principally from the standpoint of obstacles to be overcome

E. Mueller describes two such specimens. The first was taken from a girl of four years, who died of meningitis two years after completely successful reduction. The socket had the shape of a regularly rounded, hollow shell, forming more than two-fifths of a circle. The base was covered with a smooth layer of cartilage The roof of the socket was broad but still composed chiefly of cartilage The femoral head formed a ball corresponding to the socket and was in intimate contact with it The capsule stretched tensely from the rim of the socket down to the neck of the femur No abnormal protrusion could be observed

Mueller's second specimen was taken from a girl of 2½ years, who died of pneumonia six to seven weeks following reduction The hip which at autopsy was still in the primary position, showed no conformity between the femoral head and the socket The socket was saucer shaped, while the head still showed a medio-posterior flattening and between the head and the socket were several interspaces filled with loose fatty tissue. The condition of the capsule was of special interest The posterior superior portion, into which the femoral head had previously fitted no longer bulged but was shriveled into numerous folds, which no longer permitted any reconstruction of the highly arched peak of the capsular hood Anteriorly the capsule was stretched taut over the femoral head pressing the latter

into the socket. According to Mueller, shrinking of the capsule requires at least an interval of three to four months.

Nové-Josserand was able to examine the joint of a child of three years, who died of diphtheria one and one half years after reduction. This child had already been walking for three months. The joint showed a somewhat exaggerated forward protrusion of the femoral head and a slight tendency to outward rotation Otherwise the position of the joint as a whole was completely normal. As regards the changes in the base of the socket, aside from the fact that the fatty tissue had disappeared only in the gaps, the cartilaginous and bony socket had grown larger This was due not only to the fact that the formerly inward turned rim of the limbus was now turned outward but also the entire previously perpendicular anterior third of the acetabular margin was leveled to a flat arch The capsule showed only a somewhat poorer development of the supporting ligaments, but otherwise normal conditions

v Bayer was able to show changes in the plastic cartilaginous tissue of the joint bodies following reduction with resulting mutual moulding of the joint bodies and a deepening of the socket. Even this adjustment would in itself increase the contents of the socket. At any rate the raised acetabular margins and a limbus closely approximating the head contributed still further to this end

Putti made a study of the anatomic conditions in the two hips of a girl of two and one-half years who succumbed in a thymus death six months after reduction. He noted good adjustment with beginning manifestations of a reconstructive reaction process in the acetabular ring The most important feature disclosed at autopsy was a profuse connective tissue proliferation throughout the joint These proliferations covered the entire floor of the socket with a dense thick layer The latter extended in the form of plates and fibers from the synovial surface of the capsule to the circumference of the femoral neck and in broad layers over the femoral head, so that the latter had lost its natural gloss. The bilateral absence of a well differentiated pulvinar indicated that this structure was compressed



Fig 87 Congenital dislocation of the left side in a girl one year of age

following reduction and became mixed with the proliferating connective tissue covering the base of the socket The limbus was pulled down by the capsular hood and tended to reinforce the capsule which appeared atrophied especially in its posterior and superior parts and was shorter and thicker than normal Putti s specimen showed very clearly the process of plastic adjustment of the joint to the new conditions imposed by reduction

The changes described above as springing from the healing process can be followed in part in the roentgenogram Already Dreesmann observed in one case that even fourteen days after reduction the femoral head appeared in the roentgen image 1½ cm. closer to the floor of the socket He concluded therefore that resorption of the hypertrophic acetabular contents



Fig. 88 The same case as in Fig 87 after closed reduction in accentuated primary position

takes place very rapidly with cartilaginous elements likewise being resorbed or transformed

Usually after nine to twelve months, frequently even during the period of fixation, appositional changes can be demonstrated on the posterior rim of the socket in the form of jagged processes protruding like columns and corresponding to the progressive ossification of the posterior rim of the socket Also the upper rim of the socket undergoes ossification with formation of exostoses like projections. Gradually the irregularities even out more and more, the roof becoming more and more distinct About two years after reduction one may frequently already find normal conditions (Figs. 87 88 and 89)

It cannot surprise us that replacement of cartilage by bone tissue should occur slowly, and that at least two years should be required for ossification especially of the upper rim of the socket. For this reason the hope of anatomic restitution need not



Fig. 89 The same case as in Figs. 87 and 88 at the age of six years. Normal anatomic condition of the reduced hip hardly to be distinguished from the normal right side.

be abandoned even though the process may require a longer time. In this connection Gill's observations are of great interest. In a series of cases he was able to show that although no acetabular roof could be demonstrated in the roentgenogram *even years after reduction the same socket might later show a* perfectly normal development. In the final analysis, therefore, functional stimulation had produced its effect.

If the head is adjusted concentrically, then a reshaping of the head takes place in which it approximates the normal configuration. From this change in the shape of the head and from the ossification processes it is possible to determine whether the head is adjusted concentrically, thus indicating a good prognosis. After three to four years a sclerosis of the acetabular contour constituting the termination of the regenerative processes is usually demonstrable (Figs. 90, 91 and 92). *Premature* sclerosis of the roof of the socket while it is still perpendicular precludes

Fig 90 Bilateral congenital dislocation in a boy 4½ years of age with marked displacement (luxatio supracotyloidea et iliaca)

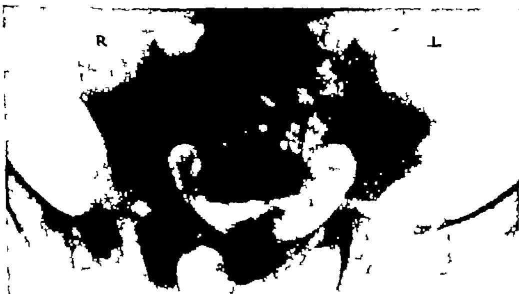


Fig 91 The same case as in Fig 90 following closed reduction, in accentuated primary position. The femoral heads were brought down by preliminary skin traction. Note the marginal proliferation at the upper rim of the acetabulum as a sign of beginning development of the acetabulum.

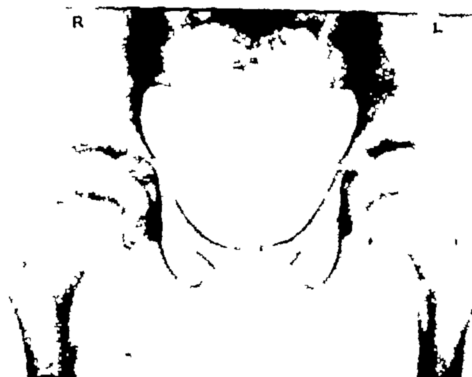


Fig 92 The same case as in Figs. 90 and 91 three years later at the age of seven years. Perfect anatomic healing on both sides

further bone development and must be regarded as an unfavor able prognostic sign (Fig 93)

Francillon considers the *question of ossification of the ace tabular margin* and in particular of the acetabular roof to be intimately related to the development of the ossa acetabuli which can often be seen also in the roentgenogram as a small acces sory ossification nucleus on the cranial margin of the acetabulum Francillon draws from this fact the practical conclusion that this structure must be left intact and that reduction over the superior rim of the acetabulum is therefore absolutely contra indicated

If the adjustment of the head is not completely concentric during the primary position, or if an initially correct primary position is not maintained for a sufficient length of time or in the *presence of unfavorable anatomic conditions* especially with a more marked anteversion [illegible] al neck there results an *excentric* f[illegible] the



Fig 93 Bilateral congenital dislocation in a girl four years of age, two years after closed reduction. *Premature sclerosis* of the roof of the acetabulum demonstrates termination of the regenerative process. No further development can be expected.

In this event, the original socket is not found deepened as a whole but there is always also a portion of the cartilaginous roof of the socket involved in its formation. This does not constitute any ideal result, but rather the beginning of subluxation. In bilateral dislocation, it occurs frequently enough that one side shows a concentric acetabular formation, and the other side an excentric formation

The studies and observations here presented indicate that the constituent tissues of the joint (supporting and connective tissues) possess an extraordinary capacity for regeneration. *The power of regeneration is particularly active in the first and second year of life,* but may exert its formative effects even later

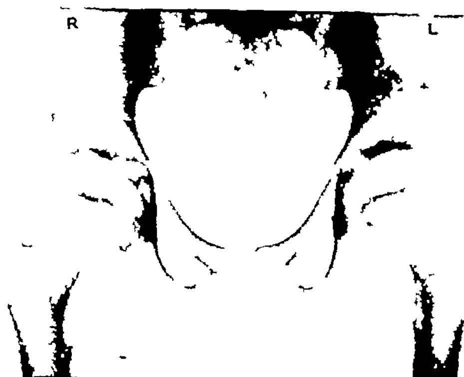


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Fig 93 Bilateral congenital dislocation in a girl four years of age, two years after closed reduction. *Premature sclerosis* of the roof of the acetabulum demonstrates termination of the regenerative process. No further development can be expected.

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in certain periods of increased sensitivity to functional stimulus. The regeneration of the connective tissue and cartilage takes place fairly rapidly, that of the bone somewhat later. At any rate, up to a certain age the properly reduced and sufficiently long retained femoral head *is* capable of *exerting a formative* effect or stimulus on the cartilaginous layer of the socket, which is still in the stage of intensive growth. The insufficient base of the socket may thus develop to such an extent that it will finally suffice to retain the head permanently.

It has been *demonstrated beyond question by the basic con*tributions of J. Wolff, Roux and others, that joint reconstruction is accomplished by *functional adaptation* as well as by the *natural tendency toward replacement of basic substances*. And it is just as certain that the earlier and more completely the normal function of the tissues is restored, the more easily will the organism adjust itself.

We have seen that under the stimulus of function even at the pathologic site, a neoarthrosis develops which possesses a certain degree of functional capacity even if not wholly normal. *How much more readily may this development be expected in a physiologic site, where the natural conditions for such a nutritive and formative development of the joint are available.*

G. RESULTS OF CLOSED REDUCTION

The question as to the *results obtained by closed reduction* in dislocation has long been the object of serious study by orthopedists of nearly all nations. The reported data are contradictory in so many respects, that it is almost impossible to prepare a generally serviceable statistical presentation. The different *interpretations of success* are *not surprising* considering the lack of agreement as regards the conception of "cure." Whereas formerly a cure was conceded in all cases in which the X-ray showed the femoral head approximately at the level of the socket beneath the roof of the socket, thus including lesser degrees *of subluxation, at present by* virtue of the experience gained from the follow-up of cases reduced several years back, this conception of cure has been considerably limited. Today the ma

jority of orthopedists agree that only those cases can be regarded as definitely cured in which a *complete anatomic restoration* can be demonstrated, with a roentgenogram showing no difference between a normal and reduced hip

Another controversial point is the conception of the time interval necessary for evaluation of end results. Whereas many writers believe that a lapse of three years from the time of reduction suffices for an evaluation of end results, others extend this period even up to *ten years*

Still another difficulty is presented by the fact that only a small fraction of the available material can be used for statistics, so that the end results indicated would have only relative significance.

In attempting a review of the available data, a conclusion would be justifiable only after taking into consideration the above mentioned sources of error

In any numerical evaluation of the results obtained, the older statistics usually differentiate only between unilateral and bilateral dislocation In a collective German review begun in Germany by Deutschlaender and continued by Reiner, including thousands of cases the percentage of cures reported by various surgeons in unilateral dislocation varies from 8 per cent to 78 per cent, and in bilateral dislocations from 0 per cent to 75 per cent Other statistics show little more uniformity Thus Lovett and Soutter reported anatomic cures in 71 per cent, Kirmission in 11 3 per cent and Froehlich in one third of all cases Nové-Josserand reports 61 per cent of perfect functional end results Haglund otherwise a very objective observer, was so optimistic that he envisioned the time rapidly approaching when 100 per cent of cures might be expected in unilateral dislocations, and 60 to 70 per cent of cures in bilateral dislocations Waldenstroem reports more than 64 per cent of cures and Epstein in Russia more than 42 per cent On the other hand, Broca and D Intignani reported only ten normal joints in a series of 357 cases. Stephens reported very poor results. His follow-up in older cases treated during the years 1891 to 1910 showed that the reduction had been maintained in only 15 per cent of the cases

One point evidently not given consideration in these statistics, and at least as important as the uni-or bilaterality of the dislocation, was the *age* of the patient at the time of reduction

Lorenz presents statistics of end results in 477 unilateral and 290 bilateral dislocations. He emphasized the fact that the criteria of cure were strict, and that many of the unclassified results could still be considered as a marked improvement over the initial condition These cases were divided into age groups.

Good End-Results in 767 Cases of Closed Reduction According to Lorenz

Unilateral Dislocations (477 cases)

Age	No. of cases	Cures
2	193	60%
3	122	67%
4	70	61%
5	45	47%
6-7	26	47%
8	21	46%

Bilateral Dislocations (290 cases)

Age	No. of cases	*Cures on one side*	*Cures on both sides*
2	68	36%	49%
3	62	50%	34%
4	59	56%	24%
5	35	58%	15%
6 7	47	65%	13%
8	19	31%	5%

The dependence of good results upon the age of the patient is evident. Patients with unilateral dislocations operated upon in the *third* year have the best results, i.e cures in 60 per cent of cases. In patients beyond this age period, the percentage of cures falls rapidly to reach 46 per cent in patients of eight years of age

This question of end results became a subject for heated discussion also later on. In 1921 the *American* Orthopedic Association appointed a committee to investigate the end results after a period of at least three years, including Goldthwait, Adams and Ridlon The problem was approached from various angles, but *no definite* conclusion could be reached because the

data presented at that time were insufficient to solve the problem

During the same year there was a convention of the *French* orthopedists in Strasbourg, in which among others, Froehlich, Estor Nové-Josserand, Roederer and Gourdon took part. At this convention, the chief topic of discussion was that of the end results of congenital dislocation of the hip following closed treatment. It was agreed to include for evaluation only such cases as had been reduced at least *ten* years earlier

In 1929, there was a Congress of the *German* Orthopedic Society in München at which M Lange presented a comprehensive study of the end results of C D H His material was collected from three German clinics, and included 1 450 cases, with 2,200 reduced hips, from the year 1904 to 1925 The treatment of these 1 450 cases differed in the different clinics. Some were reduced by the Lorenz method, some according to the technic of Schanz, Gaugele, Lange and Schede. In the group of cases reduced from 10 to 15 years earlier, *anatomic cure was obtained in more than 50 per cent*, i.e. the roentgenogram showed a normal picture, the joint was freely movable and function uninhibited. If cases with good function were included as good results, then the percentage of satisfactory results of treatment could be estimated as *75 per cent* of cases. The majority of cases with good end results had been reduced between the ages of *one* and *two* years. Attainment of a good permanent result is rare after the fifth year

These experiences of Lange are in general agreement with those of F Schede. He distinguishes between primary and final end results Primary results are demonstrable four years from the time of reduction up to the time of puberty Final results are those observed after puberty Primary anatomical cures may persist through puberty without retrogression Primary functional results may undergo exacerbation during puberty For this reason, only results after puberty should be designated as end results. Schede's after-examinations included cases reduced in the period 1924 to 1929 in which reduction had been accomplished 10 to 15 years previous. Among these, were a considerable number which were already past the age of puberty

Seventy-four cases were followed up and good results were recorded in 50 per cent Reluxations occurred in only one per cent of the cases. These findings were in agreement with those of other writers, indicating that cases in which reduction was completed before the third year of life and in which a completely normal joint was obtained, remained permanently cured

As regards our personal experiences, obtained from the material at the Vienna Clinic during the years 1901 to 1923 it must be kept in mind that the majority of our patients were recruited from the most various parts of what constituted the Austrian Kingdom at that time, and that after its dissolution after the end of the first World War, these patients were scattered to all points of the compass. Many of them could not be located and from others only scant information could be obtained by letter

The result of a survey was as follows Of a total of 2 138 patients treated by the Lorenz method only 414 returned for examination and X-ray control, i e only about one fifth of the cases In all cases, the period of follow up was five to ten years or more. The cases were divided into three age groups, the first between one and three years the second between three and six years, and the third group above six years of age The results are shown in the following table

End Results in 414 Controlled Cases of Closed Reduction According to Hass

Age	Type of dislocation	Results: excellent	good	fair	poor
1 3 years	unilateral	53 %	36%	8%	3%
	bilateral	42%	29 %	17%	1
3 6 years	unilateral	29%	25%	27%	19
	bilateral	21%	31	25	23
over 6 years	unilateral	6%	12%	33	49
	bilateral	—	9	28	63

In the first age group of one to three years, excellent results were obtained in about 50 per cent of cases. Then the percentage of good results dropped rapidly in the next age group The results were considerably less favorable in patients of the same age group with bilateral dislocations.

Of special interest are the statistics of Italian writers.

Putti (1934) reports 523 re-examined cases treated during the years 1899 to 1927, with an observation period of a minimum of four years and a maximum of seven years following closed reduction All cases were treated according to the Paci-Lorenz method The results were indicated by means of a numerical system from 0 to 10 as ranging from complete failure to a perfect result Putti likewise distinguished between anatomic and functional results The anatomic results were obviously determined by the X ray findings A careful analysis reveals that of a total number of 284 cases treated in the period from 1899 to 1920 the percentage of good anatomic results was 22 87 per cent, that of good functional results 29 57 per cent Of a total number of 239 cases treated during the period of 1921 to 1927, the percentage of good anatomic results increased to 47 68 per cent, and that of the good functional results to 53 12 per cent. The total number of unilateral cases from 1899 to 1927 was 287 Of this number the anatomic results were good in 41 86 per cent and the functional results were good in 50 50 per cent. Of the total number of 236 bilateral cases, during the same period, anatomic results were good in 25 per cent and functional results were good in 27 96 per cent In the total series of 523 cases, redislocation occurred in 4 58 per cent

In summarizing the total number of controlled cases (523 cases) treated between 1899 and 1927, it is thus evident that good anatomic results were obtained in 34 22 per cent and good functional results in 40 34 per cent Putti concludes that judging from the progress in treatment during the last ten to fifteen years, the total percentage of good results should have increased by approximately ten points, i e., from 40-45 per cent to 50-55 per cent.

Following the same principle of examination and continuing Putti's statistics Scaglietti, in 1940, called in all cases treated between 1928 and 1934 In an analysis of the results, he has combined the later figures with those of Putti. Of the 3055 patients contacted, only 914 or 26 64 per cent, returned for re examination The percentage of final results shows no essen-

tial difference from that reported by Putti in 1932 Good results were obtained in an average of 45-50 per cent of cases depending upon the age at which reduction was performed

According to Poli (1935) at the Clinic in Milano, closed *reduction was performed in 7,561 cases, or 90 01* per cent of the total number of 8,196 cases treated during the period from 1903 to 1936 In this record are included the statistics from the same clinic published by Annovazzi in 1932 Poli divides his cases into four age groups the first group includes patients under two years of age the second group patients between two and five years of age the third group patients between five and 10 years of age and the fourth group patients of more than 10 years of age The number of controlled cases is not stated.

Results of Closed Reduction According to Poli

Age	Type of dislocation	Good results	Satisfactory results	Poor results
Under 2 years	unilateral	82 02%	9 54%	8 39%
	bilateral	49 52	37 93 %	12 55
2 5 years	unilateral	66 10%	14 09 %	19.72%
	bilateral	32 98%	39 86%	27 15 %
5 10 years	unilateral	15 85 %	6 09	78 04 %
	bilateral	17 85%	3 57	78 56%
Over 10 years	unilateral only	16 66	8 33 %	74.99 %

Taking into consideration the period of observation the percentage of good results in this series would be as follows

Cases reviewed 5 yrs. after reduction	unilateral	71 82%
	bilateral	40.26 %
Cases reviewed more than 5 yrs. after reduction	unilateral	61 56%
	bilateral	35 85

The average percentage of good results is, therefore 52 07 per cent

Poli separates the cases of *primary subluxation* from the general group of luxations. The treatment was, however practically the same as for true dislocation. Child of less than 1-1½ years of age were with abduc inward rotation in casts, and mo by the a *of Putti's* splint for 4 to 8 months. beyond classical *Paci Lorenz reduction* w results the same as in true dislocations. I ith su however

there occur a greater percentage of redislocation and, of course, a larger number of later deforming arthroses.

Of no less value than the above mentioned extensive German and Italian statistics, would be in our opinion the complete detailed records of relatively small series of cases such as those published principally by American writers (Farell, von Lackum and Smith, Steindler, Kulowski and Freund, Severin Gill and Ponseti)

Farell, von Lackum and Smith (1926) reported 310 cases of C D H treated at the New York Orthopedic Dispensary and Hospital from 1900 to 1920 In 85 patients, the condition was bilateral, thus making a total of 395 hips treated. Of 310 patients the final result could be definitely determined in 266 cases with 336 hips. The most recent cases were treated not more than five years before these statistics were published

Of the 266 cases, including 196 unilateral and 70 bilateral cases, one or both hips were retained in the socket with a good functional result in only 103 cases, or 39 per cent. However, among the 61 percent which were not retained were 40 cases, or 15 per cent, which were counted as fairly good functional results. In 17 cases, including 24 hips, and comprising 5 per cent of the total series, no reduction could be accomplished. During the next ten years, 156 additional hips were treated by closed reduction, and good reduction was maintained in 44 per cent of these cases for an average follow-up period of eight years, and a minimum of two years.

In a report by Steindler Kulowski and Freund (1935), on 378 hips treated in the period from 1915 to 1933, closed reduction was accepted as a method of choice within the upper age limits of five years for bilateral, and six years for unilateral cases. Only a few cases were treated in the first and second year of life. While five years was considered the upper limit for closed reduction, the latter was attempted in only 249 cases with 319 hips.

In most of the cases the method used was that of Paci-Lorenz and as a rule, the hip was immobilized in the primary Lorenz position for about three months then the leg was brought down to Lange s position and immobilized for another

three months. Walking exercises were initiated at an average of six to eight months after immobilization. The observation period was from one to 20 years after reduction.

Results of Closed Reduction in Relation to Age Groups According to Steindler, Kulowski and Freund

Age at time of reduction	Results			
	Good	Fair	Poor	Undetermined
1 to 2 years	46.14%	7.69%	38.45%	7.69%
2 to 3 years	55.33%	12.62%	20.38%	11.65%
3 to 4 years	44.17%	12.80%	30.23%	12.80
4 to 5 years	24.37%	18.75%	37.50%	9.37%
5 years and over	25.71%	17.14%	51.42%	5.71%

An average of 55 per cent of satisfactory results was therefore estimated. Good results decrease with age and results grow definitely less favorable as the duration of the period of observation increases.

The above report was later supplemented by *Ponseti (1944)* to include 103 additional cases treated by closed reduction at *the Steindler Clinic.* Good *anatomic results* (well developed hip joints) were reported in 12 cases, or 11.6 per cent of the series and good functional results in 47, or 45.6 per cent.

Severin (1940), a pupil of Waldenstroem, reports results of closed reduction in 306 cases re-examined in a follow-up series five to twenty-seven years after the beginning of treatment. The series included *116* bilateral and *190* unilateral cases, and *417* hips in all. The age at which reduction was performed varied greatly. Eighty four per cent of the patients were treated before their fifth birthday. The oldest was a girl with unilateral dislocation treated at the age of 12 years. Severin considers five years the minimum time required to elapse before end results can be judged.

According to the roentgenologic features of the joint he classified his cases into six groups: Group I normal hips, Group II moderate deformity, Group III dysplasia without subluxation, Group IV subluxation, Group V the femoral head articu-

lating with a secondary acetabulum in the upper portion of the original socket, Group VI re dislocation

Late Roentgenologic Results in 417 Re-examined Hips According to Severin

Group	Bilateral cases (227 hips)	Unilateral cases (190 hips)
I.	1 32%	8 42%
II.	5 29%	10 53%
III.	5 29%	12 63%
IV	49 34%	44 21%
V	15 45%	12 11%
VI.	23 35%	12 11%

Of the late functional results, about one-fourth were perfect at least five years after reduction If to these are added the good, or satisfactory results, the proportion is brought up to about two-thirds.

Gill (1943) presented a very careful study of the end-results of closed reduction in 126 hips He classifies his end-results as perfect, excellent, good and satisfactory The perfect hips have a normal anatomic structure as demonstrated in the roentgenogram. The excellent cases show normal function (absence of fatigue, pain and limp) even though roentgenographically the anatomic structure of the hip cannot be considered perfect The terms good and satisfactory indicate freedom from symptoms but the presence of even more marked anatomic defect

Of the 98 hips which had been under observation for eight years and more, only 14 showed perfect results and seven excellent results. But these included only the known or proved results. The estimated successful closed reductions constituted therefore, 34 7 per cent of the series of 98 hips The results of closed reduction in bilateral cases were as good as in the unilateral cases. Some hips attained a normal or perfect structure soon after reduction Others attained this result only after many years. One striking fact apparent from his statistics was that the greatest number of relapses (33) occurred during the first years following closed reduction, with a decreasing incidence in succeeding years. Although Gill s statistics were based

on a comparatively small number of cases, the real value of his study lies not so much in the end-result percentages, as in the light he threw upon the subject of treatment from the very beginning to the very end.

In a more recent review (1948) Gill presents the following end results. Of 53 cases treated by closed reduction and followed up for a considerable period of time (at least three years), the end results were as follows:

End Results in 53 Controlled Cases of Closed Reduction According to Gill

Perfect results	17 cases	32.07%
Excellent results	11 cases	20.76%
Satisfactory results	15 cases	28.30
Failures	10 cases	18.87

The time required for restoration of normal anatomical relations varies greatly. In some cases, restoration was manifest as early as three years after reduction. In others, it might be delayed to the time of puberty. Good end results depend to a great extent upon the age of the patient at the time of the reduction, the technic of procedure, and proper after-care. Some observations suggested that the reactive capacity may be of just as great importance as the time factor in the restoration of a perfect hip.

Bost, Hagey, Schottstaet and Larsen (1948) presented a report of results obtained in a series of 112 hips in 86 patients treated within the first three years of life, covering a period from one to 13 years after the commencement of treatment. The patients included in this study were treated by a number of surgeons, and therefore the type of treatment varied considerably. As a rule, the treatment consisted of closed reduction by the method of Denucé. In some cases, the original manipulation was preceded by application of a traction splint as recommended by Coonse. In some cases, following immobilization in a plaster cast for approximately five months, the plaster cast was replaced by a Ponseti bar.

Excellent or nearly excellent anatomic results were obtained in 55.4 per cent of the 112 cases and functional results were ex

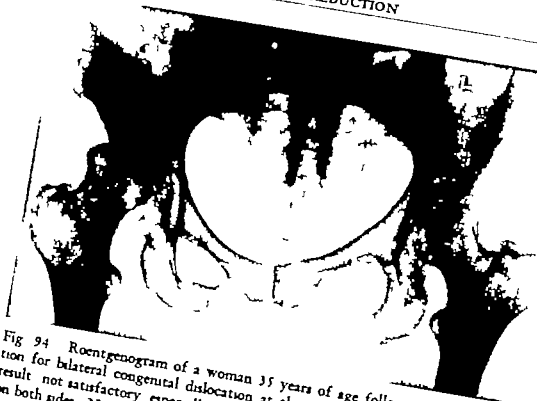


Fig 94 Roentgenogram of a woman 35 years of age following closed reduction for bilateral congenital dislocation at the age of three years. Anatomical result not satisfactory especially on the right side. Functional result excellent on both sides. No limp no pain.

cellent in 60 7 per cent. There is a direct relation between the early institution of treatment and the good reports obtained The authors urge greater effort toward earlier recognition of dislocation and toward improvement in the present methods of treatment.

In reviewing the studies of the end-results of closed reduction, it is obvious that many cases can be completely cured by closed reduction and by skillful management of the whole procedure The number of perfect results, however is much smaller than was anticipated in former years. However, the percentage of good results following closed reduction varies according to whether the clinic reports any considerable number of follow-up cases. Attempting to discover the cause of the frequently contradictory reports, we will find that one of the chief causes lies in the lack of uniformity in selection of cases Particularly in the older statistics, numerous cases far exceeding the age limits were included Furthermore it has to be taken into account that in

many cases of that period treatment was still very imperfect Certainly the reduction and after-care did not everywhere receive the requisite attention

Another fact which helps to explain the contradictory findings is the disparity in the *classification* of the end results. Most writers are satisfied with reporting only "cured" cases, ignoring all other degrees of amelioration Surely, a perfect anatomic restitution must be the objective aimed at by treatment However, in evaluating the worth of the treatment one must take into consideration not only the anatomically perfect results, but also anatomically less satisfactory, but functionally favorable results. Even though a joint may not be perfect as far as anatomic restoration is concerned, it may from the patient's and functional point of view be considered satisfactory (Fig 94) On the other hand there are cases in which adjustment appears perfect roentgenographically, but in which a more or less complete ankylosis of the joint must rate as a failure In bilateral cases, results often differ markedly in the two hips. Quite frequently the disability in the imperfectly reduced hip is less than that in the perfectly reduced hip *Invaluable as x ray examination is for control of clinical findings, evaluation of results cannot be based exclusively and solely on the roentgen findings.*

In place of the categorical classifications of "cured" and "non cured" which often permits an arbitrary interpretation it would in our opinion seem more accurate to make use of the current standard of grading in judging the end results in agreement with Kidner Krida Colonna and Carr This offers us the following classification

I *Excellent* when the gait is completely normal pain free and steady the Trendelenburg sign is negative, and when the x ray shows completely normal anatomic conditions.

II *Good* when the gait is normal the Trendelenburg sign negative even though the x ray shows moderate deviations *from the normal* such as a slightly excentric position

III *Fair* when limping and dragging follow prolonged walking with a slight Trendelenburg sign and the x ray shows defi

nite changes, such as flattening of the acetabulum and mild degrees of subluxation.

IV *Poor* all other cases, in particular those with a positive Trendelenburg sign, a definite limping gait and beginning or manifest redislocation All cases with ankylosis of the joint should also be included in this group

Cases in the first group are considered as definitely cured, and also cases in the second group may be expected to remain reduced The cases in the second group, may, however, later in life show degenerative changes of the bone in the nature of an osteoarthritis due to irregularities in the joint surfaces. Cases in the third group have a dubious future. Many of these patients may improve but others may turn out worse and a relapse may occur years after treatment.

A future follow-up system should be based on a classification like that just described Furthermore, the age of the patient at the time of reduction must always be taken into consideration, as well as the time that has elapsed since reduction *From our experience we can assume that in patients who were treated at the age of 2 or 3 years and showed perfect results at the age of 5 or 6 years, these results will remain If however the anatomic result is not satisfactory at this age, the condition may become worse at the time of puberty* Since results may change considerably during the course of years, and especially during the critical period of puberty, *it is probably unwise to draw conclusions as to end results* before the patient has passed the age of puberty Results of treatment before 10 years after reduction cannot be regarded as end results

Considered from this angle, we find that even the pessimistically inclined allow *excellent results*, corresponding to anatomic and functional cure, in *about one-half of cases in which the dislocation was reduced during the first three years of life* From a practical point of view, treatment may also be considered successful, in cases in which the characteristic limp of dislocation has permanently disappeared, when the joint is freely movable, and the roentgenogram shows a sufficiently shaped joint, even though the critical eye of the anatomist may not admit a perfectly normal joint

H FAILURES OF CLOSED REDUCTION

1 REDISLOCATIONS

Below is a comparison of statistics on the incidence of redislocation

	No. of controlled cases	Redislocations
Ludloff (1911)	384	11.6%
Lorenz (1920)	767	10 %
Adams (1921)	195	17.4%
Lovett and Soutter (1922)	235	8 %
Noré Josserand (1928)	212	6.5%
M Lange (1929)	1450	4.5%
Putti (1934)	523	4.38%
Poli (1937)	—*	13.9%
Gill (1943)	98	65.3%
Ponseti (1944)	103	7.7%

* Number of controlled cases not stated

On the whole the number of redislocations is smaller now than formerly, when treatment was very imperfect The unusually large number of redislocations reported by Gill, can be explained by the fact that he included in his group of redislocations all cases showing even the slightest roentgenographic evidence of subluxation.

We must distinguish between early redislocation i.e., cases in which signs of redislocation appear while the limb is in the cast or shortly after its removal, and late redislocation which may develop years after apparent cure

a) *Early Redislocations* Redislocations which become manifest while the limb is still in the cast are usually due to inadequate reduction or to interposition of a soft part or to carelessness in changing the cast Redislocations which appear after the cast treatment may be due to any of the following causes

1 A deficient, not accurately concentric primary position

2 A primary position, correct per se but not long enough maintained

3 Particularly unfavorable anatomic conditions, leading to an excentric formation of the acetabulum

4 Absence or retardation of development of the roof of the socket

5 Especially in older children a rigid flexion contracture of the hip joint during the period of after-treatment, which under the strain of weight-bearing and in the presence of a diminished resistance of the atrophied portions of the capsule may lead to yielding of the latter and redislocation

Various degrees of redislocation may be observed from simple subluxation and the relatively slighter anterior redislocation to complete redislocation on the posterior surface of the ileum. The anterior redislocation may constitute either an adjustment to the anterior superior rim of the socket, or medial from the rim of the socket on the upper branch of the pubic bone. In either case a marked prominence of the femoral head can be palpated anterior in the inguinal fossa Posterior redislocation occurs usually when the primary position is gone, and differs in no respect from the original iliac dislocation.

With regard to the *interposition of soft parts* as a cause of redislocation, this may be caused by a fold in the capsule intruding below and posteriorly between the head and the socket, or by an elongated and thickened lig teres Ludloff has drawn attention to the part played by an inward turned limbus in preventing retention Deutschlaender found that in old cases, the chief obstacle was a displacement of the ileopsoas tendon, favoring the formation of a capsular isthmus M Lange observed interposition of soft parts in about 5 per cent of redislocations. Putti draws attention to the fact that adhesions of the capsule may also have some part in causing redislocation, and that, in particular, adhesions of the capsular hood to the ileum may induce upward dislocation even after successful reduction Such a condition is encountered usually, however only after the third year of life

Opinions are divided as to the significance of *anteversion* as a cause of redislocation Some writers (F Lange, Gaugele, Gocht) refuse to recognize anteversion as favoring redislocation Others, such as Lorenz Brandes Schede, and Hibbs consider anteversion an important factor in the production of redislocation Lovett assumes that about 20 per cent of redislocations can be traced to anteversion Recently, on the other hand Ponseti in a series of 28 redislocations and four subluxations, could

definitely attribute only four redislocations and two subluxations to anteversion of the femoral neck

We have drawn attention in the chapter on Pathology to the fact that anteversion has frequently been overrated in its significance for the development of C D H (p 63) But even though its importance may have been exaggerated as a causative *factor in the pathogenesis of dislocation* we cannot afford to *underestimate* the role of anteversion as a cause of redislocation If anteversion fails to *retrogress spontaneously or when the socket* cannot adjust itself to the anteverted femoral head at least to the extent that the inner posterior pole can find adequate support in the upper posterior quadrant of the acetabulum then an anterior superior redislocation would seem inevitable In many cases, however, the anteversion may have developed secondarily due to forced inward rotation or prolonged malposition of the femoral head At any rate, it is a striking fact that anteversion is found so frequently in those older cases in which the head has persisted permanently in a subluxation position and that it is usually absent in iliac dislocation (see Fig 30)

*Krida is of the opinion that the most common cause of re*lapse is a "torsion distortion of the upper end of the femur "*The struggle for stability in the early phases of ambulation* forces the dislocated head towards bony contact with the side of the ileum sometimes to a degree sufficient to produce a secondary acetabulum by constantly attempted inward rotation of the outward rotated extremity The plastic infantile femur is incapable of fully withstanding this rotary stress, and consequently develops a torsion deformity Krida therefore admits the possibility that anteversion may be produced secondarily and principally by continued inward rotation

In our opinion anteversion is irrelevant up to the third year of life In some older cases, however it cannot be denied that primary or secondary anteversion may be present and *if in ex*treme degree the femoral head may *slide forward and upward leading to redislocation*

The most common cause of redislocation must be recognized however to be primarily *failure of development of the*

cavity M. Lange estimates that a flattened acetabulum is the cause of 75 per cent of redislocations. Fairbank, Lovett and Soutter likewise found a poorly developed socket to be the most common cause of redislocation. A poorly developed socket is, to be sure, as a rule the result of an inadequate adjustment of the socket. Doubtless most of the ultimate failures should be credited to reductions performed too late to carelessness in the performance of reduction or to neglect of the painstaking after-care so necessary in these cases. It cannot be denied, however that even at similar ages, and with similar adequate treatment the development of the socket may be imperfect or fail altogether This fact forces us to the assumption that a special *constitutional* factor may be involved, connected with the *power of reaction* of the basic substance, and that such a factor may differ individually (p 00) This power may, in many cases, be so pronounced, that with the aid of the trophic stimulus, it may lead to complete healing whereas in other cases, it may be so slight that formal development may be retarded or completely lacking

The final conclusions from these practical experiences have not been reached by far, however It is necessary nevertheless, to distinguish between exogenous forces and inhibitions and the last mentioned endogenous factor The first can be modified by our medical science, but over the latter, of course, we have no power

b) *Late Redislocations* These are dislocation cases, in which reduction has been successfully completed and after years of apparent cure, usually during adolescence, various symptoms such as pain and limping develop Examination will, as a rule reveal an increasing shortening with a suggested or complete Trendelenburg sign The femoral head is lateral and forced upward out of the socket, and only partly surrounded by the socket. The cause of these late redislocations is believed to be trauma or body weight increasing with age Schanz in accordance with his general conception of insufficiency symptoms believes that the cause may be an insufficiency of the hip

joint, i e, a disproportion between the strain on the joint and its powers of resistance

On the other hand, the author has been able to demonstrate roentgenographically that the primary cause lies in *anatomic*

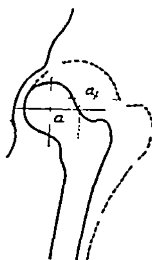


Fig 95 *Late redislocation* due to disproportional developement of the socket and femoral head. a. Concentric position of the femoral head. b. Excentric position after upward and outward migration of the capitular axis.

changes, and that the insufficiency develops only as a result of these changes. From the observation of 14 cases, he has demonstrated that these late changes occur only in an *anatomically incompletely restored joint*

If such cases are followed up at continuous intervals, it may be observed that the acetabulum and the femoral head do not always develop at the same rate and that this difference in rate of development is most marked at certain ages, namely toward the fifth and sixth year of life and later especially during the period of puberty Simultaneous with acceleration of longitudinal growth at the time of puberty the joint passes through a most critical period It is at this stage that the epiphyses and their adjoining skeletal parts undergo the most intense metabolic process of ossification. During this critical period there may occur a flattening of the already insufficient socket which is confronted with an unproportionally large head The cause of this difference in the rate of growth is probably the fact that the acetabulum being the seat of the primary growth disturbance is retarded in development while the head is able to develop quite freely (Fig 95)

The immediate result of this difference in the rate of growth of the head as compared with the socket is at first an excentric outward and upward migration of the capital axis and a *displacement of the articulation* of the upper rim of the socket, which is soon smoothed down and transformed into a gliding furrow It is, therefore, here at the superior quadrant of the socket that the now incongruent head begins to deviate upward with the simultaneous yielding of the lateral portions of the capsule which are unable to withstand any prolonged pressure It is also at this time that the strain makes itself felt, giving rise to severe drawing pains in the predominantly ligamental fixation apparatus With a simultaneously increased outward rotation of the limb, the body weight contributes what then is needed to complete subluxation and force the head entirely out of the socket (Fig 96 97 and 98)

A further fact of considerable influence in the development of late redislocation is the *adduction contracture* of the hip which is a common associated symptom of late redislocation Whether the adduction contracture is caused mechanically by the upward migration of the femoral head or is due to a disturbance in muscular equilibrium, is of little consequence. The fact is, that this adduction contracture presents an additional factor by increasing the otherwise present tendency to dislocation.

There are, however, also other causes which favor redislocation at a later age. Such causes are presented by the change in statics of the entire pelvis caused by lowering of the pelvis on the contralateral side. Thus in bilateral cases, due to abduction on one side the *other* hip may be forced into an adduction position which with the additional factors of predisposition may produce even after a lapse of years a dislocation in this hitherto stabile side (Figs. 99 and 100)

As we have seen every deficiently developed socket thus furnishes a latent tendency to late redislocation, which remains imminent as long as an adequate socket roof of fixed shape fails to develop and at least until the patient has passed beyond puberty



Fig. 98



Fig. 97
(See legend opposite p. [illegible])



Fig. 96

Because of this possibility of redislocation after many years it is necessary to emphasize the importance of *anatomic* restitution in determining the later fate of reduced luxations. The most important precaution is to search for symptoms of late redislocation in time so that preventive measures may be instituted

c) *Treatment of Redislocations* When the hip slips out of place during the period of plaster fixation, it should be replaced immediately, by subjecting the hip to a more marked accentuation of the primary position (p 179) In these cases, fixation should be prolonged for three to six months

As regards redislocation after termination of the period of fixation, a renewed attempt at manual reduction will usually fail, owing to the same lack of stability present in the first reduction. If an interposition of soft parts is suspected, one must proceed at once to open reduction. In other cases we wait until about the fifth year before deciding to resort to radical measures. Otherwise experiences have shown that some cases redislocated during the first years owing to a poorly developed socket, may, following repeated reduction years later be retained permanently Furthermore, a case reported by Bade demonstrates that even in interposition of soft parts, the prognosis need not be altogether hopeless If the obstacle to retention consists of a capsular interposition, such a capsular fold may become atrophied and disappear after a sufficient period of fixation.

As regards anterior redislocation it should be noted that it shows a relatively slight tendency to shortening and that even without special measures, the functional result may often be so satisfactory that radical measures may be dispensed with.

←

Fig 96 Development of a late redislocation on the basis of deficient development of the socket. Roentgenogram of a girl three years of age one year after closed reduction. Poorly developed acetabular roof

Fig 97 The same case as in Fig 96 at the age of seven years The femoral head displaced definitely upward

Fig 98 The same case as in Figs. 96 and 97 at the age of 18 years. The head is considerably larger and further displaced upward It is no longer supported by the roof of the acetabulum.



Figs. 99 and 100
(See legends opposite page.)

Special attention must be directed to the treatment of *late* redislocations. The simplest measure to combat a threatening late redislocation is the previously described girdle which is used also occasionally in the after-care of congenital dislocations of the hip with a deficient development of the roof of the socket (see Fig 85) If nothing else, this will exert a lateral pressure and cause a close approximation of the femoral head to the lateral wall of the pelvis In addition to this measure, weakening of the musculature should be combatted by abduction exercises and massage of the gluteal muscles.

If a definite redislocation is already manifest, with more marked adduction contracture, and if the measures just described have failed to bring about the desired results, a satisfactory outcome is to be hoped for only by application of surgical treatment. This may consist of palliative or reconstructive intervention, as will be discussed later

An important problem is how to proceed in the presence of obstacles presented by *anteversion*

According to our experiences, a spontaneous improvement is possible in anteversion following reduction If this spontaneous correction does not take place, and if the socket cannot adjust itself to the anteverted femoral head, correction may be required in such cases.

In the year 1910, Lorenz advocated a simultaneous *supracondylar osteoclasis*, and accomplished both reduction and correction of the existing anteversion simultaneously The original reduction was performed first, and then at the *same* sitting the thigh was manually fractured over a wedge in the supracondylar region whereupon the distal fragment was rotated outward in proportion to the degree of anteversion Naturally the knee and lower leg down to the toes was included in the cast.

←

Fig 99 Beginning late redislocation due to tilting of the pelvis on the contralateral side. Roentgenogram of a girl of three years with luxatio supracotyloidea on the right side and sliding groove without displacement on the left side.

Fig 100 Roentgenogram of the same case as in Fig 99 five years after closed reduction at the age of eight years Owing to the persistent abduction of the right side, the normal but predisposed *left* hip is forced into *adduction* and has produced in the course of years a dislocation of the hitherto stable left hip

After three months, when the fracture was healed the lower leg was liberated

The author recollects that in the Vienna Clinic at that time, more than 100 cases were treated in the manner just described The results showed little improvement, however and the method was therefore abandoned There were, moreover other determining reasons for departing from this technic, namely to begin with, the increased bone atrophy due to osteoclasis, which doubtless had a very deleterious effect on bone development and secondly, the necessity for including the knee and lower leg in the cast, and thus interfering for a long time with any active muscular movement.

The strongest argument against the early correction of anteversion is the fact that in children *up to three years of age anteversion is irrelevant in relation to treatment and requires no correction* If the theory of anteversion were otherwise correct, then it would hardly have been possible to achieve any cure of C D H without osteoclasis.

In opposition to this theory, Krida is of the opinion that anteversion should be corrected as early as possible His procedure is as follows *The hip is first reduced over the posterior* rim of the acetabulum (following preliminary suitable stretching of the adductor region) The limb is then fixed in the ninety ninety position Two weeks later if no abnormal anterior dislocation can be demonstrated the limb is fixed in mild inward rotation and diminished abduction If abnormal anterior distortion is present the limb is fixed in a degree of inward rotation *sufficient to completely overcome it* The inward rotation is corrected in the second sitting approximately three months after beginning treatment by manual *fracture of the femur in the* supracondylar region and by suitable outward rotation of the lower fragment

The limb is fixed in moderate abduction with slight flexion at the hip and moderate flexion at the knee of sufficient degree *to maintain the rotated position* of the fragments In unilateral cases a simple spica bandage for ambulation is applied after six weeks. In bilateral cases, a *longer period of fixation* is recom

mended, followed by a period of rest in bed, with massage, active joint mobilization, and rest and sleep in a plaster bed

Krida, Colonna and Carr report a series of 66 patients, treated according to the technic described by Krida Their series included children up to three years of age, chiefly from the Hospital for the Ruptured and Crippled, from 1925 to 1931 Of the 66 cases, 43 were unilateral and 23 bilateral, making a total of 89 hips treated Correction of anteversion by osteoclasis was performed in 77 hips, or 86 per cent.

Good results were obtained by this method in 75 per cent, fair results in 19 per cent, and poor results in 6 per cent. In the bilateral cases the results were good in 65 per cent fair in 17 per cent, and poor in 18 per cent.

Although we have adopted the standpoint that anteversion presents no serious therapeutic problem in children under three years of age, we believe nevertheless, that marked pathologic anteversion in older cases may jeopardize the results of reduction and require correction

Among the procedures for correction of anteversion in older cases, may be mentioned the *subtrochanteric rotation osteotomy* which was first advocated by Schede, in 1897 According to his technic, the dislocation of the hip is first reduced and the limb is fixed in marked inward rotation and in abduction of 40° 60 After three months, and with painstaking maintenance of this position, a subtrochanteric osteotomy is performed, and a long nail is driven subcutaneously into the trochanter and neck of the femur against which the inferior fragment is rotated outward Schede recommends that for purposes of stretching of the outer rotators, the outward rotation should be of a degree exceeding that of the anteversion The entire extremity is fixed in an accurately modelled plaster cast. This cast is left in situ for six weeks to three months. The nail is removed after five weeks. Later, Schede recommended that the osteotomy be performed in the supracondylar region, about a hand s breadth above the condyles.

Codivilla presented a modification of the Schede operation He performs reduction in inward rotation, introduces the nail, and applies a long plaster cast in which the nail is included After

ten days he cuts away the lower portion of the cast to the margin of the middle and inferior third of the thigh at which site he performs an osteotomy, giving the peripheral fragment the proper outward direction and then again applies a cast

Rotation osteotomy to correct the anteversion by rotating the distal fragment outward, was also done by Hibbs, Sherman and others. Hibbs performed the osteotomy before the closed reduction, at the lower third of the femur Sherman did it about *two months after open reduction.*

Like Schede, we perform a subtrochanteric osteotomy three months after reduction and introduce *two* Steinmann pins instead of one into the shaft of the femur one above and one below the site of osteotomy Both nails are included in the cast, and are removed after six weeks. After another six weeks the entire cast is removed

Subtrochanteric osteotomy is preferable to the supracondylar osteotomy, because it is closer to the site of the deformity and thus prevents any disturbance of the muscles of the knee In our estimation, this operation is indicated in from four to five per cent of cases of any age

2 Post reduction Deformities of the Upper End of the Femur

Besides the early and late redislocations, postoperative changes *of the upper end of the femur also threaten the reduced hip* These changes affect both the femoral neck and epiphyses of the head, and may exert considerable influence on the further fate of the reduced hip *Redard, Alsberg Ludloff Curtillet Bulling er Mueller Froehlich Nové Josserand Morel Wullstein Van Neck* and others, were the first to draw attention to these changes. Further reports followed With regard to the incidence of these changes, opinions differ sharply Whereas, for instance Redard reports only one case of coxa vara in a series of 500 treated cases of dislocation Puerckhauer found coxa vara in 47 5 per cent of all reduced cases, changes in *the femoral head developing* in part during treatment and in part after treatment In roentgenograms of 200 reduced dislocations I gloff found pathologic changes in the head and neck of the femur in 52 5 per cent of the cases



Fig 101 Post reduction changes in a boy with bilateral congenital dislocation at the age of 16 years Closed reduction at the age of 4 years. There is marked coxa vara and plana on both sides. Patient walks with a limp

This high incidence has been questioned by other writers, such as Galeazzi and Spitzy and has frequently been attributed to faulty projections in the roentgenograms, besides to later arthritic changes It is suggested that these deformities of the femoral head and neck may be simulated by an abnormal position of the leg in the roentgenogram M. Lange found coxa vara in only 3.5 per cent of his cases. From his material, one may at least conclude that the incidence of postoperative changes in the upper end of the femur has probably been largely overestimated in the earlier writings

Coxa vara during the period of fixation in a cast is rare. As a rule it develops later after the patient begins to walk, and may be related to insufficiency of the femoral neck to resist excessive functional strain (Fig 101)

Besides coxa vara, there are postoperative changes in the *epiphyses of the femoral head* which present important factors to be reckoned with. Brandes was the first to recognize the similarity of these changes to those in Legg-Perthes disease. Later,



Fig 102 Legg Perthes disease of the right hip following closed reduction a girl two years of age Note the diminution of the epiphyseal nucle marked disturbance in the bone structure

numerous writers have discussed this phase (Puerckhauer Horvath Biebergeil Bade Schwarz, Amstad Soederlunc in Gaugele Spitzy Matsuura Hilgenreiner Nagura and The well known clinical symptoms corre ie recurring identical roentgen picture, ferent stages of development In the l tion of the epiphyseal nucleus of the ances in bone structure Later on contours of the epiphyses with den stance fragmentation of the epiphy nation in a cylindrical or mushroom *generative process is finished* Occa femoral neck may be observed as processes are subchondral in the bon cartilage intact but may later lead



Fig. 103 The same case as in Figure 102 Fragmentation of the epiphyseal nucleus.

atrophy of the epiphysis of the femoral head (Figs 102 103 and 104)

Putti describes an *epiphysitis* of the epiphysis of the femoral head and distinguishes three types

1 *Pyknosis* of the epiphyseal nucleus. This is the most common form of epiphysitis, manifested by a densification of the epiphyseal nucleus. It frequently occurs very early, occasionally as early as the second month following reduction In most cases, however, it is seen toward the end of the fixation treatment. Frequently the neck also is involved in the process, and becomes shorter and broader, with a tendency to varus deformity

2 *Lacunar dissolution* of the nucleus. In this type the epiphysis is infiltrated with lacunae and grooves from the beginning, giving it a sieve-like or reticular appearance.



Fig 102 Legg Perthes disease of the right hip following closed reduction in a girl two years of age. Note the diminution of the epiphyseal nucleus with *marked disturbance in the bone structure*

numerous writers have discussed this phase (Puerckhauer Egloff Horvath, Biebergeil Bade Schwarz Amstad, Soederlund Sever in, Gaugele Spitzy Matsuura Hilgenreiner, Nagura and others) The well known clinical symptoms correspond to the constantly recurring identical roentgen picture which differs only at different stages of development In the beginning there is a diminution of the epiphyseal nucleus of the head with marked disturbances in bone structure Later on there is a loosening of the contours of the epiphyses, with densification of the bony substance fragmentation of the epiphyseal nucleus, and final termi*nation in a cylindrical or mushroom shaped head* when the regenerative process is finished Occasionally a broadening of the femoral neck may be observed as a sign of regeneration The processes are subchondral in the beginning leaving the articular cartilage intact but may *later lead to complete collapse and final*



Fig 103 The same case as in Figure 102 Fragmentation of the epiphyseal nucleus.

atrophy of the epiphysis of the femoral head (Figs. 102, 103 and 104)

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Fig 104 The same case as Figures 102 and 103 Termination of the epiphyseal nucleus in a disk shaped epiphysis.

3 *Cystic degeneration* of the nucleus. Here we have to deal not with densification or fragmentation but with a more or less extensive vacuolization of the nucleus, without any changes in its circumference In form and structure it resembles the cystic rarefactions occasionally encountered at the iliac margin of the acetabulum.

On the basis of his observations in 18 cases at the Istituto Rizzoli Freund concluded that most of the deformities of the femoral head described as late deformities, are caused by an articular process becoming active immediately following reduction In his opinion the articular process may be either one of two essentially different forms, one being designated as the *osteochondritic* type and the other as *arthritis*

Putti does not recognize a primary osteochondritis following reduction but believes the change to be a secondary manifestation since as a rule it is encountered at a later date long after reduction when the development of the epiphysis is already complete He suggests that some *trophic* disturbance due to circulatory deficiency is responsible in which the traumatic changes or pressure changes in the lig teres may play a special part

A feature occasionally observed in the regenerative stage, is a prominence of the lateral portion of the femoral epiphysis, projecting beyond the upper rim of the socket. This results in a mechanical block to abduction

The incidence of these changes in the femoral head can be estimated only from a study of the more recent literature since Legg-Perthes disease was unknown to the older writers. It was also formerly often confused with arthritis. According to M Lange, changes in the femoral head may be observed in about 20 per cent of his cases. Bilateral dislocations show a higher incidence of such changes than do the unilateral dislocations.

There appears to be a striking relation of these anomalies of the femoral head to the age of the child at the time of reduction. Thus 50 per cent of all deformities of the femoral head are found in children who were five years old or older at the time of reduction. Deformities of the femoral head are relatively rare in the first two years of life However, children in the first two years of life are not immune to such changes, as demonstrated in the statistics of Hilgenreiner, who found osteochondritic changes in 28 of 157 cases in the first year of life, i.e. in 17 8 per cent

The pathogenesis of the changes in the femoral head following reduced dislocation of the hip is confused not a little by the lack of uniformity in the nosology of Perthes disease. Many writers consider the *trauma of reduction* as the cause of these deformities (Bibergeil, Froehlich, Horvath) The trauma of reduction, in particular the forced maneuver in older children, may cause injury to the epiphysis and thus predispose the latter to disturbances In addition we may possibly also consider the damage inflicted on the tiny vessels of the lig teres, which carry part of the blood supply to the epiphysis The blood supply to an initially poorly nourished and predominantly cartilaginous femoral epiphysis might thus be still further impaired. In these cases, Axhausen s conception of an *aseptic necrosis* due to bland mycotic embolism in the distribution of the afferent vessels would seem amply justified Crego and Schwartzmann treat all cases with preliminary traction, usually skeletal traction and claim that in a series of seventy-eight congenital dislocations of

joint of defective "anlage" react more sensitively to various stimuli than those of a normal joint The pressure persisting for months following reduction on the predominantly cartilaginous and thus less resistant epiphysis, is probably responsible for initiating the osteochondritic process

It is possible that also the atrophy of the bone in the long period of fixation may play an auxiliary part.

As for the treatment of Legg-Perthes disease as a sequel of reduction of the hip the only method hitherto suggested has been complete relief from weight-bearing until regeneration is attained. The time required for complete regeneration averages from three to four years. Many advise rest in bed with continuous traction We have never been able to reconcile ourselves to this radical measure, which dooms the patient to years of invalidism and excludes him from all activity, especially since the limb can be spared by use of a suitable supporting apparatus (caliper brace with ischial seat) With the latter, the child can move about freely and may also attend school In many cases, however a deformity of the head in the form of a coxa plana will persist with a corresponding limitation of abduction

Post-reduction changes may involve not only the femoral head, but also the *socket* Roentgenographically, such changes usually appear as cystic rarefactions in the roof of the socket. Frequently they appear at a later date following reduction and may be interpreted as degenerative manifestations of slight significance (Fig 105)

Of greater importance are those late changes in the constituents of the hip joint of the nature of a *degenerative osteochondritis*, which develop on the basis of a retarded flat acetabulum, and frequently lead to marked deformities Some of these patients may do surprisingly well in spite of the deformity of the femoral head, but in later life, when they reach the age of 40 to 50 years, pain and disability may develop (Fig 106)

Post reduction complications with other diseases are extremely rare. One case of *tuberculosis* of the hip following closed reduction has been reported by Pease, another by Grospic. The case described by Pease was that of a girl of eight years with a typical history of C D H on the left side Closed reduction was accom-

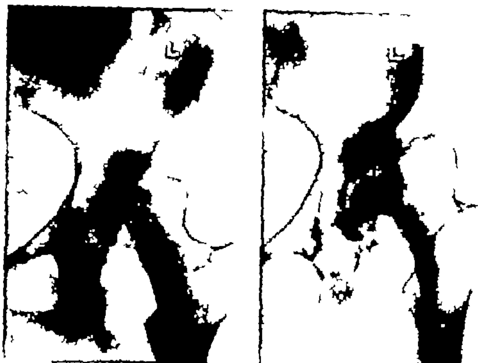


Fig. 105 Roentgenogram of the left hip in a woman 27 years of age. Closed reduction was performed at the age of four years. Note the flattening of the femoral head and the cystic rarefaction in the roof of the socket.

Fig. 106 The same case as in Fig. 105 10 years later at the age of 37 years. *Marked hypertrophic osteoarthritis. Pain and disability have developed.*

plished when she was six years old, but subluxation required further manipulations and casts. Because of persistent pain and limitation of motion in all directions owing to muscle spasm a biopsy was performed which revealed tuberculous granulation tissue. Therefore in all cases of persistent pain and spastic restriction of motion in all directions following reduction of C.D.H. a careful study should be made for possible secondary infection of the joint.

From these experiences in the pathogenesis of the postoperative changes in the femoral head and acetabulum we recognize the necessity for following up roentgenologically at regular intervals, at least twice a year, all children with reduced hip joints. Only such constant control exerted over a period of years can yield information as to the presence of any of these untoward conditions.

Chapter XII

OPEN REDUCTION

A TECHNIC

AS MENTIONED EARLIER, POGGI (1888) WAS THE FIRST TO ATtempt to replace the dislocated femoral head in the socket, after deepening the latter for this purpose. Hoffa (1890) adopted Poggi's idea and succeeded in developing open reduction into the generally accepted method of that period. Lorenz improved this method by utilizing an incision sparing the pelvitrochanteric muscles, which are so extremely important from a functional point of view. A series of excellent results were obtained by the Hoffa Lorenz method.

The Hoffa Lorenz technic. The anesthetized patient is placed on the operating table in a semi-lateral position. Longitudinal traction is exerted on the limb by means of a strap about the ankle with countertraction about the perineum. After pulling the femoral head down to the level of the socket, and under continuous traction, the cutaneous incision is started at the anterior superior iliac spine and continued downward and outward for 6 to 7 cm in the direction of the external margin of the tensor fasciae. The fascia lata is then split above and below along the external margin of the tensor. The anterior margin of the gluteus medius is then pulled firmly backward while the tensor, together with the adjoining sartorius and deeper lying rectus femoris is pulled firmly forward thus exposing the capsule. The joint is opened by splitting the capsule in the direction of the femoral neck from below the inferior spine to its insertion in the anterior root of the femoral neck. If necessary, a second transverse incision is made, forming a T with the first incision. The femoral head is then exposed and the lig. teres extirpated if presenting. In moderate adduction and outward rotation the head is displaced outward to render the socket accessible. Deep-

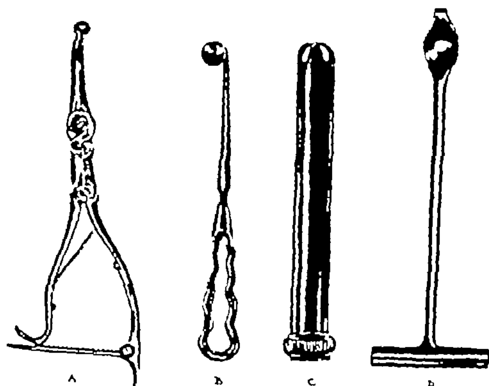


Fig 107 Special instruments for open reduction. A The Putti spreader for dilatation of the isthmus. B. The Lorenz curette for removing fat and fibrocartilaginous tissue from the acetabulum. C. The Murphy reamer for reaming out the cavity D The Codivilla lever for reducing the head into the socket.

ening of the socket is accomplished by removing the fibrocartilaginous masses within it Lorenz has recommended a curette of corresponding shape (Fig 107B) for this purpose Hoffa used the Doyen socket drill Only in very rare instances was any attempt made to mould the femoral head. Reduction of the femoral head was accomplished by increased longitudinal traction achieved by rotating the abducted limb inward and pressure on the trochanter In difficult cases the lever described by Codivilla (Fig 107D) was used and greatly facilitated replacement of the head in the socket Lorenz believed that suture of the capsule was unnecessary After proper wound care a plaster cast extending to the toes was applied in full extension *slight abduction of about 50* and moderate internal rotation

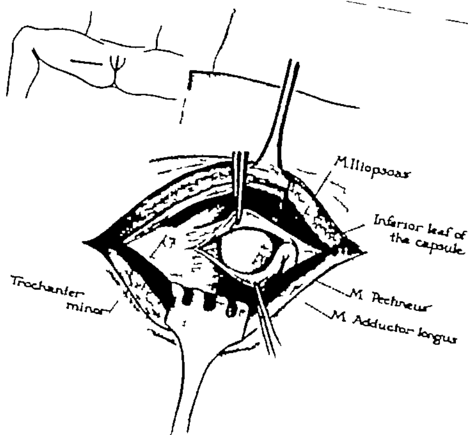


Fig 108 Arthrotomy according to Ludloff for removal of capsular inter position. Exposure of the hip joint in primary position The lower leaf of the capsule is interposed Insert shows position of the skin incision

At the end of the sixth week the cast was removed. The after-treatment was otherwise conducted according to the same principles as for closed reduction The tendency to ankylosis is, however much greater than following closed reduction Only gradual and careful mobilization, eventually with the aid of renewed bed traction will give a satisfactory result.

Ludloff's technic Ludloff (1908) suggested a very different plan of operation. In cases in which closed reduction had failed, he placed the child even though still unreduced for three to four weeks in a plaster cast in the Lorenz primary position. Only then did he proceed to perform the operation in the same position. The skin incision extends along the lateral margin of the adductor magnus (Fig 108) The vessels are retr-







Fig. 109 Unilateral dislocation of the left hip in a girl three years of age

Fig. 110 The same case as in Fig. 109 immediately following an attempt at closed reduction There is evidence of interposition and the head lies below the acetabulum and at a distance from the acetabular floor

Fig. 111 The same case as in Fig. 109 and 110 after arthrotomy according to Ludloff The inferior leaf of the capsule was found interposed and was excised Perfect result

upward, thus exposing the capsule. Following incision of the capsule, the acetabulum lies fully exposed in all detail Any resistance to reduction is overcome until it is possible to place the head in the socket. No deepening of the socket is attempted The capsule is closed as far as possible with a few sutures the cutaneous margins exactly approximated and sutured, and the limb immobilized in the primary position The advantages of this method include adequate exposure of the socket, insignificant bleeding, and insignificant damage to the capsule. We have used the Ludloff technic with excellent results in very young children, under three years of age, with evident signs of capsular interposition (Fig 109 110, and 111) In some cases we were able to push the lower leaf of the capsule, which was caught between the head and the acetabulum out of the way In other cases, complete excision of the fold was necessary This can easily be accomplished under direct vision. The method seems to us less well suited for older patients owing to inaccessibility of the area of neorthrosis above the socket.

Deutschlaender, a staunch advocate of open reduction performed this operation also in older patients of more than fifteen years of age. He placed the cutaneous incision along the adductors, and once the stump had been retracted continued right on to the insertion of the adductors He used a curved transverse incision to open the capsule, thus facilitating upward retraction of the latter The femoral head was reduced into the socket with the aid of a bone hook After-treatment consisted of fixation in abduction of 45° However satisfactory some of the functional results obtained by this method the anatomic results were always poor

The Lorenz method of closed reduction and its rapidly increasing popularity soon forced open reduction into the background and during the next two decades, closed reduction became the method of choice

Disgusted with the variable results of closed reduction Sherman (1904) strongly opposed the manipulative procedure. He claimed that "it is nearly always a physical impossibility to pass the head through the constricted part of the capsule without enlarging the opening with a knife"

Galloway an enthusiastic exponent of Sherman's procedure definitely abandoned the manipulative method, and used open reduction in almost all cases at any age, even without any preliminary attempt at closed reduction For most children under six years of age Galloway employed the anterior incision but in older patients, he used the posterior incision Later he preferred the Smith Petersen approach to the hip To support his theory that all cases should be treated by operation never by manipulation alone, Galloway presented the following report of his results. Of fifty open operations conducted in a series of 37 patients, seven operations in four of the patients consisted of removal of the femoral head In three other cases, the operations were secondary interventions on hips which had been operated upon before but which had redislocated and in two cases the results were unknown. Of the total of 38 operations in 31 patients available for final evaluation a cure was obtained in 12 instances, good results in 14 failures in six and doubtful results in 6 cases. There were six cases of infection and one death. Among the cases classified as good results, there was one case in which neither hip was in the acetabulum, and a few cases with complete ankylosis. It is clear that these results could hardly be expected to arouse enthusiasm for the open operation Nevertheless in the following years, the interest in open reduction has shown signs of revival here and abroad. Many methods of open reduction have been recommended and many cases have been treated by open reduction (Allison Kidner Tubby Lambotte Deutschlaender Thomas, Fairbank Davis, Dixon, Albee Willis, Clarke Putti Gill Leveuf, Stewart Schede Colonna and others)

The technic of choice is that of Putti. The guiding principle of his procedure is arthrotomy, paving the way for reduction. It involves no reaming out of the glenoid fossa decortication of the cartilage or reshaping of the epiphysis In other words, all these procedures directed toward adaptation of articular components are abandoned. The operation is made as simple as possible leaving the epiphysis such as it is to be placed as gently as possible in the socket such as it may be while observing the most rigorous respect for the integrity of the bony components

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of the joint Thus we have a wide exposure of the joint, with removal of all *non osseous* obstacles Reduction itself, for which the arthrotomy is but a necessary preliminary act, is performed essentially in the same manner as for closed reduction

Putti's tecnic as described by Putti and Zanoli The patient is placed on the Putti table, which permits longitudinal traction on both limbs. Putti uses an anterolateral approach, reaching the joint between the lateral border of the sartorius and tensor fasciae and deeper down, lateral to the rectus (Fig 112) It is a broad, safe approach to the capsule, and has only one disadvantage When the dislocation is very marked, the femoral epiphysis remains hidden behind the tensor and partly below the gluteus medius. He therefore recommends that the upper end of the incision be extended obliquely upward parallel with, and one finger breadth below the crest of the ilium. In this way the entire thickness of the tensor and the anterior fibers of the gluteus medius are divided transversely one or two centimeters below the iliac crest, and the muscles are detached from the bone. Thus the space between the sartorius and tensor is widely exposed offering a better view of the entire capsular field covering the epiphysis. In the depths, the capsule covering the head is exposed between the rectus and the tensor In the distal portion of the wound appears a branch of the lateral circumflex femoral artery, accompanied by one or two veins and a small branch of the femoral nerve This is ligated and divided The aponeurotic sheath extending between the rectus and lateral vastus, is divided in the line of the incision, thus exposing the whole capsule The capsule is opened by an oblique incision from above downward, exposing the entire epiphysis. This incision is then extended distally to expose the neck of the femur Upon outward rotation of the limb the epiphysis will then slip out of the capsular opening It is then necessary to study the communication between the upper portion of the capsule and the acetabulum, to determine whether the isthmus is open or closed In the presence of a free communication with the acetabulum, which is more favorable but less common, the isthmus is dilated with a special spreader (Fig 107A) Between

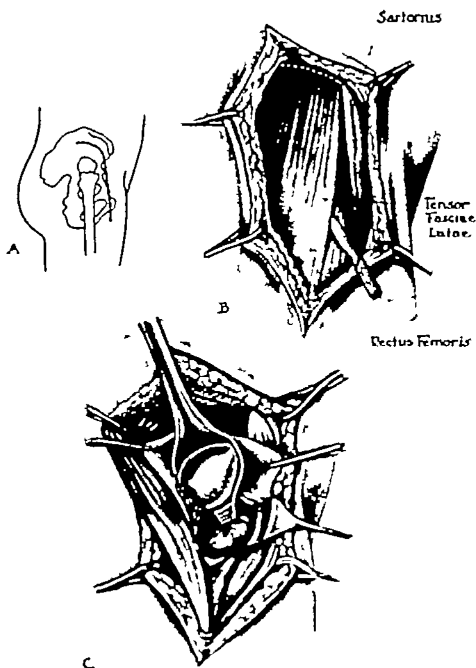


Fig. 112
(See legend opposite page.)

the open branches of the spreader, the anterior wall of the isthmus is then divided further down to give a complete exposure of the whole socket. An important guide to the acetabulum is the lig teres, which must not, therefore, be removed until the base of the socket has been definitely identified In most cases, however, the path to the acetabulum is closed by a capsular barrier, which is hard to identify It is then advisable to remove with scissors the whole wall of the isthmus, beginning from above and proceeding downward to the acetabulum This is the most tedious part of the operation due to bleeding from the capsule, and to the fact that not only the capsule of the isthmus, but also the capsule covering the socket has to be removed Finally, the upper rim of the socket, covered with glistening white cartilaginous tissue, is reached. The fossa itself may occasionally be difficult to recognize because it is hyperplastic and usually filled with amorphous cellular tissue. The latter should be gently removed with the scissors and forceps, taking care *not to injure the articular cartilage*

At this point, when the cavity is free, traction of more than 20 kilograms is applied to the leg As a rule, in children four to six years of age, if the dislocation is not too severe, this will suffice to bring the head down to the level of the socket Reduction can then easily be accomplished by a movement of internal rotation and progressive abduction If the traction is not sufficient to overcome the resistance of the pelvio-femoral muscles, it is discontinued, and the classic maneuver of the Paci-Lorenz method is applied. Or, the hip may be reduced over the upper rim of the socket For this maneuver Putti uses Codivilla's lever (Fig 107D) This lever is placed behind the femoral head, and simultaneous with gradual abduction of the thigh, the head is pushed slowly down This must be done very gently in order to avoid injury to the femoral head It was Putti's experience that the most frequent obstacle to reduction was the pericapital

Fig 112 *Putti's* method of open reduction. A Indicates skin incision B Antero-lateral approach between tensor fasciae and rectus. The dotted line indicates the division of the tensor below the iliac crest. C Following completed opening of the capsule and access to the cavity of the acetabulum, the femoral head is carefully pushed beneath the margin of the limbus with the aid of a Codivilla lever (redrawn from Putti and Zanoli)

insertion of the capsule (p 70) When this is present the capsule must be detached all around the periphery of the epiphysis.

As regards the position for retention that best suited to maintain the head in the socket must be checked as long as the joint is open As a rule the best position for this purpose is 40 to 50° abduction plus more or less pronounced inward rotation In some cases it may be preferable to put the limb in the right angle Lorenz position The limb is then fixed in the optimum position in a plaster cast suitable to the age of the child In cases in which the Lorenz position is chosen which is usually in younger children the plaster is changed after one and one half to two months The thigh is then placed in traction for ten days and the position is gradually changed to the Lange position which is maintained for one and one half to two months more If the Lange position is chosen from the beginning then the cast is not changed but is left in situ for two or three months in all

After removal of the plaster cast the usual course of physiotherapy is instituted Weight bearing is permitted only one month after removal of the cast in younger children and after two months in older children

According to Putti and Zanoli during the thirty years 1899 to 1930 there were 2 994 cases of C D H treated at the Istituto Rizzoli Of these 94 or 3 1 per cent were treated by open reduction Significantly only a few open operations were undertaken in the earlier years (only two or three cases annually) whereas in the later years (1926 1930) the number of open operations had already increased to 36 cases

The difficulties developing from the tendency to ankylosis especially in older children those chiefly involved led to measures resembling the *arthroplastic* methods for surgical mobilization of ankylosis of the hip Thus Lexer recommended removal of the entire capsule as in routine arthroplasty for ankylosis of the hip joint deep excavation of the socket remodeling of the femoral head and envelopment of the latter in fat flaps before reduction Doyen employed fascia lata for the same purpose Codivilla recommended freeing the femoral head with its surrounding joint capsule at the pelvis and its reduction together

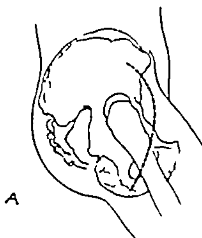
with the capsule into the excavated socket. Also Hey Groves
reduced the femoral head together with the capsule into the
socket, and anchored the head in its new bed by means of sutures
through the floor of the socket.

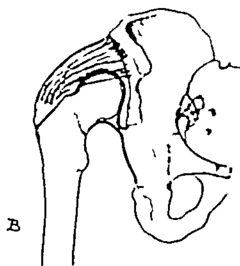
An excellent procedure was presented by Colonna (1932).

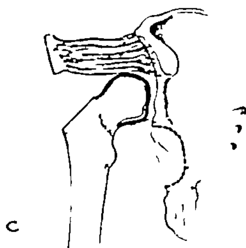
Colonna's technic. The *first* stage consists of pulling the femoral head down to the level of the original acetabulum, either manually, or by a preliminary period of skin or skeletal traction. Countertraction is exerted on the opposite limb which is immobilized in a plaster spica. The soft tissues must be completely relaxed before the second stage of the operation can be undertaken.

The *second* stage consists of exposure of the hip joint by the lateral route (Fig. 113). Beginning a finger's breadth posterior to the ant. sup. spine, the incision is curved downward crossing the shaft of the femur a few inches below the tip of the greater trochanter. Following division of the fascia lata, and medical retraction of the tensor fasciae, the tip of the greater trochanter is resected and turned upward together with its attached muscles. Then the capsule is separated from the overlying group of muscles, and is divided at its narrowest point to expose the femoral head. Following external rotation of the shaft of the femur, the capsule covering the head is liberated from the posterior muscles. No attempt should be made to reconstruct the head and the capsule is closed over it with interrupted catgut sutures. The proximal residual portion of the capsule about the rim of the old socket is removed as completely as possible. With the limb in external rotation and sharp adduction the site of the original acetabulum can then be easily recognized. At this site a capacious cavity is then reamed out with a large cûrette or a Doyen reamer. Owing to the thickness of the innominate bone a remarkably deep excavation can be obtained.

Gently and without the use of a skid the capsular-covered femoral head is then thrust deep down into the newly formed socket which may necessitate placing the limb in marked inward rotation. If so, a supracondylar osteotomy with derotation is performed a few weeks later. No effort is made to fix the capsule covering the head to the socket. Within a few weeks the outer


A


B


C

surface of the capsule will adhere firmly to the bony surface of the newly formed acetabulum The greater trochanter, with its attached muscles is then sutured back in position. A transfixation of the greater trochanter is superfluous, but following apposition of the fragments, a few interrupted catgut sutures are placed in the soft cartilaginous tissue The wound is closed in layers. With the hip in complete extension and slight abduction of about 20 , a unilateral plaster spica is applied from the nipple to the toes.

Colonna emphasizes the importance of careful watching not only during the first and second stages of the operation, but also during the early postoperative period

Following removal of the cast after four weeks, and the beginning of active and passive motion in bed, with the limb suspended, redislocation may be prevented by placing a pillow between the limbs in order to maintain abduction of 10 -20 on the affected side. Colonna also recommends that traction of five to 10 pounds be applied to the limb for a few weeks following institution of active movement in bed Exercising the limb for a few hours daily in a therapeutic tank has also proved beneficial Patients are encouraged to sit up, but should lie flat on the abdomen for some time each day in order to prevent possible flexion contracture of the hip Weight-bearing is not permitted until the patient has attained considerable degrees of passive and active motion in bed and any tendency to adduction and flexion has been corrected It may be three to six months before weight bearing can be permitted for gradually extended periods daily If during this period there are the slightest signs of "tightening up" the patient must be immediately returned to bed. As a rule, traction for a few days will suffice to restore the previous range of motility Braces to minimize the effect of weight-bearing are not recommended.

There are certain indications and contraindications requiring emphasis in the care of patients subjected to this operation The operation is indicated in children under three years of age, when closed reduction cannot be obtained or when redislocation occurs. Colonna feels that the operation is especially suited for

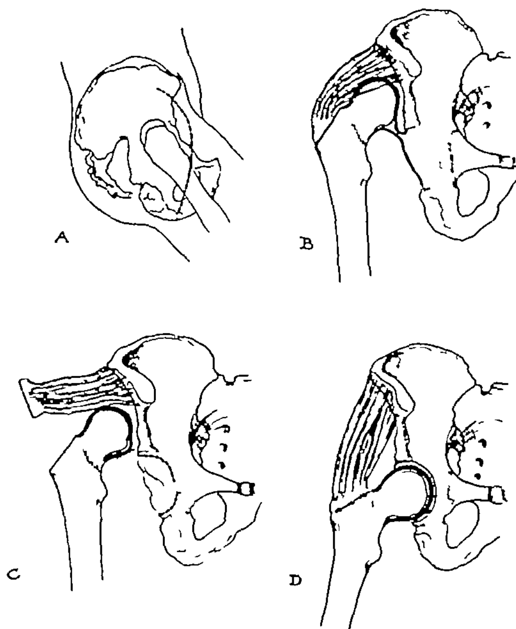


Fig 113 *Colonna's* arthroplastic procedure A. Skin incision. B. Demonstrating the method of chiseling through the greater trochanter C. The greater trochanter with its attached muscles is retracted upward and the capsule is made into a sac covering the head. A smooth capacious cavity is curetted out at the site of the original acetabulum. D The head, with its capsule is then placed in the newly formed acetabulum the greater trochanter is replaced and fixed with kangaroo sutures (redrawn from Colonna)

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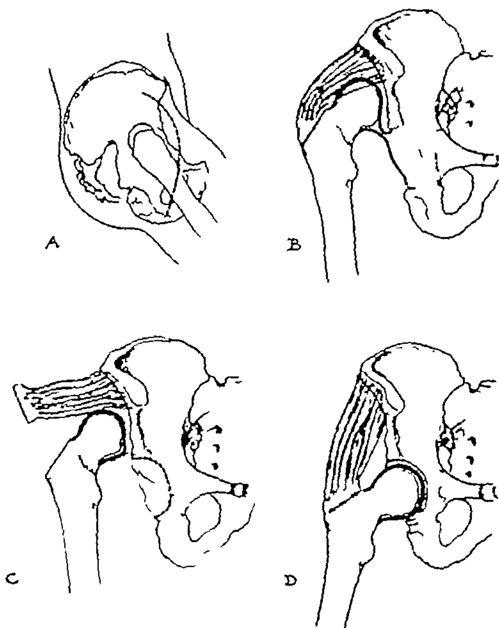


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children from three to 10 years of age but is contraindicated for unilateral dislocation in children of more than 10 years and for bilateral dislocation in children of more than eight years of age owing to the danger of later septic necrosis of the femoral head in this older group

Gill objects to Colonna s procedure, claiming that the cap sular layer covering the head will partially fill the socket and thus interfere with a perfectly concentric adjustment into the socket and favor redislocation For this reason Gill prefers to leave the acetabular cartilage intact, and in the same sitting to adequately flatten the acetabular roof to prevent redislocation

Gill s technic The incision is made along the anterior crest of the ilium to the anterior superior spine and then curves down ward and backward, as in the Smith Petersen method. Following subperiosteal detachment of the tensor fasciae and a portion of the gluteus medius sharp dissection through the anterior portion of the incision is carried downward between the tensor fasciae and sartorius, along the anterior border to the anterior inferior spine of the ilium Beyond this point the periosteum is densely adherent to the ilium. The capsule is then opened beginning at the inferior spine and the incision is extended backward for 1½ to 2 inches. Since constriction of the capsule about the femoral neck interferes with access, a second incision is carried upward at right angles from the first incision beginning in the center of the first incision and proceeding upward to the femoral head The latter can then be delivered into the wound Follow ing identification of the original acetabulum fibrous and occa sionally cartilaginous tissue as well are removed with scissors, knife or a curved gouge in order to enlarge the acetabular cavity The head of the femur is then placed in the acetabulum An ellip tical bone flap of sufficient width to cover the head and including the outer table of the ilium only is detached from the ilium and reflected downward Wedges of bone taken from the crest of the ilium are then introduced above the flap to fill in any gaps between the flap and the ilium

The upper margin of the gluteus medium and tensor fasciae is then sutured to the periosteum of the crest of the ilium and

the sartorius is sutured to the anterior border of the muscle flap For the skin sutures chromic catgut is used

The limb is fixed in a cast in moderate abduction for four weeks. Then the cast may be removed and extension is applied This is followed by the usual routine of active and passive exercises repeated several times daily, baking of the hip and massage. After 12 weeks, gradual weight-bearing is permitted

Gill summarizes the principles of open reduction as follows "1 It must be possible to place the head in the socket without undue tension upon the soft structures of the hip and consequent excessive pressure upon the articular cartilages and without injury to these structures during the replacement of the head

2 The acetabulum must be of sufficient depth to admit the entire head If the head does not lie entirely within the socket, it is subluxated

3 The roof of the acetabulum must be neither so defective nor so oblique, as to permit the head of the femur to slip out from beneath it, either suddenly or through a period of years.'

It is for this reason that it appears to the author more rational to correct this acetabular obliquity by plastic bone operation (shelf), so that the upward thrust of the head will be permanently prevented

The Hass technic of open reduction is similar to that of Putti (p 225) In children up to six years of age in unilateral cases and up to five years in bilateral cases, the operation is limited to arthrotomy and removal of all obstacles to reduction (narrowing of the capsule isthmus, adhesions, enlarged lig teres, turned down limbus, etc.) with reduction of the femoral head into a socket as nearly intact as possible. The further development of the joint can be entrusted to the natural growth of the socket. If the acetabulum is filled with fat and fibrous tissue, this can be removed with a sharp gouge But no attempt should be made to ream out the fundus of the acetabulum or to open the spongiose tissue of the socket, for this may lead to fibrous or even bony ankylosis. For the same reason, we omit any attempt to remodel the femoral head

After-treatment is based on the same principles as in closed reduction, i.e. *the hip is first fixed in the primary position and is corrected only later when the acquired stability has been tested* (p 186)

In all children more than five to six years of age with an extremely flat acetabulum, and in whom one may expect development of a normal acetabulum by functional adaptation we prefer with Gill, the combination of open reduction with reconstruction of the acetabular roof, by means of a shelf operation Undoubtedly the shelf operation will cause less stiffening of the joint than the reaming out of the acetabulum. The technic of this procedure will be described later

Smith-Petersen makes use of his vitallium mould arthroplasty also in cases of C D H

Smith-Petersen's technic In his operation the incision is carried along the anterior third of the iliac crest to the anterior superior iliac spine then downward along the mesial border of the tensor fasciae latae to a level approximately two inches below the level of the lesser trochanter The abdominal muscles, sartorius and Poupart s ligament are stripped subperiosteally and reflected mesially the gluteus medius, tensor fasciae latae and gluteus maximus laterally exposing the anterior third of the ilium The deep iliac fascia is divided between the main origin and the acetabular origin of the iliac muscle. By retracting the iliopsoas mesially the anterior and inferior capsule of the hip joint is exposed. The direct head of the rectus muscle and the acetabular origin of the iliac muscle are divided close to the anterior inferior iliac spine and reflected laterally and the capsule incised By this procedure the anterior and lateral aspect of the head and neck are exposed rendering both sides of the joint available for reconstruction

The purpose of the further steps of the operation is to create a joint with approximately normal mechanism as close as possible to the original site of the acetabulum The acetabulum and femoral head are remodelled with the aid of curved gauges and reamers and a vitallium mould applied which is loosely fitted so as to allow the greatest possible range of motion between it and

the adjacent reshaped surfaces of the femoral head and ace tabulum In order to extend the acetabular roof laterally, a vertical osteotomy of the ilium was performed.

Closure of the wound follows the lines of the approach The head of the rectus muscle is sutured to the reflected head or to

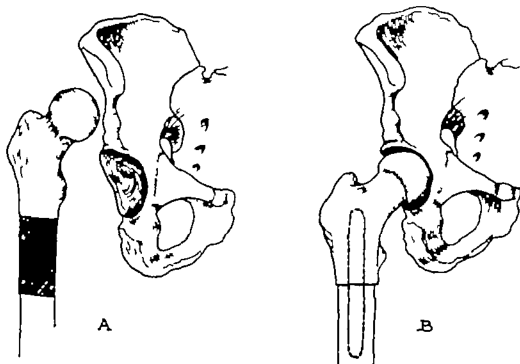


Fig 114 *Hey Groves'* operation for reducing the hip A. The shaft of the femur is shortened to allow the head to be brought down into the socket. B The shortened femur is reduced into the acetabulum, the ends of the femur being united over a peg

the central tendon of the gluteus minimus, the abdominal muscles to the other gluteal muscles and fascia without tension

There remains still another interesting surgical method to be mentioned, namely that described by Hey Groves, in which the dislocated femur is *shortened* and then *reduced* In this operation, the femur is exposed through an anterior incision with removal of a segment of the femoral shaft about two inches long below the lesser trochanter The two ends of the femur are then united over a peg By this shortening of the femur, the tension on all the great thigh muscles is relieved, and the upper end of the femur can be brought down until the head is on a level with

the acetabulum After deepening the socket the head can then be thrust into it (Fig 114) Mercer who tested this method *found that in spite of the removal of a large section of the femur,* it is still not an easy matter to reduce the head into the acetabulum and that extensive denudation of the upper fragment is required to permit adequate mobilization of the central fragment Up to the present at least the method has not been widely *accepted*

B RESULTS OF OPEN REDUCTION

Adequate statistics *of proved end results following* open reduction are extremely rare Older writers, such as Hoffa and Lorenz limit their comment to the statement that open reduction is not without risk to life, that the percentage of ankylosis and contracture is high, and that good functional results constitute the *exception It was therefore that in their time* these writers decided to discard open operation for closed reduction Also Jones and Lovett, in their *Textbook on Orthopedic Surgery* (1923) concluded from their experiences that "the reduction of congenital dislocation of the hip by the cutting operation is *not a satisfactory one.*"

A more extensive and critical account was contributed by Howorth and Smith (1932) in a detailed study of all patients treated by open operation for congenital dislocation of the hip at the New York Orthopedic Hospital between 1920 and 1929 The report includes *72 cases. At the time of operation, 16* patients were less than three years of age 39 from three to five years inclusive 14 from six to nine years and three above 10 years. Forty six cases were unilateral and 26 bilateral Of the latter only ten had double open reduction thus bringing the total *number of hips treated by open reduction to 82 No pre*liminary traction was employed in any case The Smith Petersen approach was used Simple open reduction was done in 54 per cent, reaming-out in 42 per cent, and the shelf operation in 11 per cent One patient died on the operating table

Reduction was maintained *in 61 per cent of* [illegible]
months or more after operation subluxation or [illegible] 31 per

cent, and only 8 per cent redislocated A good functional result was obtained in 67 per cent of the hips.

During the following three and one-half years, 50 additional open reductions were performed and reported by Farell and Howorth (1935) Good functional results were secured in both series in 78 per cent of the open reductions.

An interesting report of Scaglietti (1942) concerns a series of 4,990 cases of C D H treated at the Istituto Rizzoli during the years 1899 to 1938, in which 176 cases, or 3 52 per cent, were subjected to open reduction Of these 176 cases, only 49 could be re-examined following an observation period of 4 to 33 years after operation Of the total number of open reductions, good results were obtained in 25 per cent The results appeared to be particularly influenced by two factors One of these was the age of the patient at the time of operation, and the other the closed reduction treatment attempted before the operation The best results both from an anatomical and functional point of view, were obtained in cases in which open reduction had been performed before the age of four years In cases operated on between the ages of four and six years the results became worse anatomically but were still good from a functional point of view For this reason, Scaglietti is reluctant to perform open reduction after the age of five years The follow-up examination also revealed that results are constantly poorer in cases in which an attempt at closed reduction had been made previous to the operation He therefore stresses the importance of performing open reduction primarily in cases in which difficulty is anticipated in achieving closed reduction, rather than making repeated attempt at closed reduction

According to the report of Poli, of the Istituto di Milano in a series of 8,196 cases of C D H treated during the years 1903 to 1936 only 30 cases, or 0 37 per cent, were treated by open reduction. Of these 30 cases, the end results could be followed up in only 14 cases Good results were obtained in 32 per cent of patients operated upon before five years of age, and in 20 per cent of those operated on after five years of age Poli, therefore, agrees with the followers of Putti, that, whenever possible, the

the acetabulum. After deepening the socket, the head can then be thrust into it (Fig 114) Mercer, who tested this method, found that in spite of the removal of a large section of the femur, it is still not an easy matter to reduce the head into the acetabulum and that extensive denudation of the upper fragment is required to permit adequate mobilization of the central fragment. Up to the present, at least, the method has not been widely accepted.

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Colonna (1932) reported a follow up study of 56 cases treated at the *Hospital for the Ruptured and Crippled* during a nine year period from 1922 to 1930 The total number of hips operated upon was 66 All patients were between three and 25 years of age, and almost all had had one or more previous attempts at closed reduction The patients were re-examined from one to nine years after operation.

Of the total number of 66 hips operated upon seven hips were replaced after section of the contracted capsule, etc, and 31 hips following reaming-out of the acetabulum at or near the original site. In four hips, the capsule about the head was transplanted into the reamed-out acetabulum

In summarizing, Colonna concludes that this last mentioned method insures a genuine reduction of the dislocation, with the added advantage of preserving stability and motility The results in the four cases in which this method was employed were encouraging

In a later follow up study (1947), Colonna reports end results in five of the early cases treated by this method from 10 to 13 years after operation These hips showed normal function and the follow-up roentgenograms revealed remarkable restoration of joint architecture These are by far the best end results ever reported to date for open reduction

A *comparative* study of end-results of the closed and open reduction methods by one and the same responsible surgeon would, of course, have great value. The only accurate comparative analysis of results available is that reported by Kidner (1935) He studied the results in 26 cases, with 34 hips reduced by open operation and compared them with those of 13 cases with 22 dislocations reduced by the closed method. The method of open reduction was essentially like those described He found capsular adhesion to be the chief obstacle to reduction Kidner also stresses the significance of differences in size between the head and acetabulum sloping roof and anteversion or shortening of the neck, in preventing adequate replacement of the head into the acetabulum

A careful analysis of his material is presented in the following table

Comparative End Results of Open and Closed Reduction (Kidner)

Unilateral Dislocations

End Results	Open Reduction (26 cases)		Closed Reduction (17 cases)	
	No. of hips	per cent	No. of hips	per cent
Excellent	15	44 12	3	13 64
Good	11	32 36	5	22 73
Fair	2	5 88	2	9 09
Poor	3	8 82	8	36 36
Bad	3	8 82	4	18 18
Total	34	100 00	22	100 00

Bilateral Dislocations

End Results	Open Reduction (7 cases)		Closed Reduction (5 cases)	
	No. of hips	per cent	No. of hips	per cent
Excellent	3	21 43	1	10 00
Good	7	50 00	4	40 00
Fair	1	7 14	1	10 00
Poor	1	7 14	3	30 00
Bad	2	14 29	1	10 00
Total	14	100 00	10	100 00

The average age at operation with open reduction was 5-3/4 years (the youngest 1 1/2, the oldest 10 1/2 years) The average age at re-examination was 9 1°2 years. The average age at closed reduction was 2-3/4 years (the youngest 1-5/12, the oldest five years) The average age of re-examination in this group was 10-1/6 years.

In summarizing, Kidner is convinced that the results of open reduction are better than those of closed reduction, although admitting that the only perfect end-result from a clinical and roentgenographic standpoint, falls in the group of closed reduction

In a most recent contribution, Leveuf (1948) reports his results of open reduction. In his opinion the ever-recurring crux of the problem lies in the distinction between a true dislocation and a primary subluxation (p 48) He is convinced that a tru- dislocation, duly demonstrated by arthrography, must be treated by open reduction Leveuf's report covers a total number of 318

hips, operated upon during the period from January, 1941 to July, 1947 In this series, primary open reduction was performed on 119 hips, open reduction with shortening of the femur in 96 hips, and secondary open reduction for redislocation following closed reduction in 103 hips Open reduction was restricted to the removal of the soft parts blocking the acetabulum. The hip was opened by Ollier's transtrochanteric approach, which Leveuf considers best The technic of the operation has been described previously by Leveuf and Bertrand. In the procedure including shortening of the femur, he employs the technic of Zahradnicek namely a trapezoid resection at the base of the neck designed to correct simultaneously both the coxa valga and the ante version There were five deaths, three after primary open reduction, one after open reduction with shortening of the femur, and one after secondary open reduction The five deaths occurred consecutively at the beginning of 1947 and were attributed to certain disturbances in the nursing staff"

The 116 surviving cases of primary open reduction included 79 operations on patients who were three years old or under (the youngest was 10 months old) and 37 operations on patients between three and 10 years of age. Of the 116 hips, in 94 or 81 9 per cent, the results were very satisfactory (perfect results with normal range of motion or good results, with flexion of at least 90 and abduction of at least 45) The poor and bad results included reluxations in 14 7 per cent, postoperative epiphysitis in 23 3 per cent, and stiffness or ankylosis in 18 1 per cent. In the cases treated by open reduction and shortening of the femur a fair reduction was obtained in 77 per cent of the younger patients (between 3 and 15 years of age) In the adult group of 14 patients there was not a single satisfactory result. Results of open reduction following reluxation and secondary subluxation following previous closed reduction were evidently not so satisfactory as after primary reduction In 102 cases good mobility was obtained in 53 cases, poor mobility in 40 cases and complete stiffness in nine cases.

Of great interest is a report by Smith Petersen (1948) on a series of cases of C D H, in which vitallium mould arthroplasty was performed The report includes 40 cases, of which 10 were



Fig 115 Roentgenogram of a bilateral dislocation of the hip in a girl five years of age after an unsuccessful attempt at closed reduction at the age of three years. The femoral heads are behind the acetabula.

bilateral thus a total of 50 hips. The youngest patient was aged thirteen years, the oldest 60 years The results were most satisfactory The main reason for this success was probably in his opinion, the mesial transplantation of the femoral head into a new and deep acetabulum, this results in stability and improved muscular leverage so that the Trendelenburg sign is markedly diminished. According to a recent study of Stinchfield and Carroll (1949) at the New York Orthopedic Dispensary and Hospital, five of 45 mould arthroplasties were done for C D H The average age of the five patients was 23 9 years. The patients were satisfied with the results. But in a six year old child at the end of two years after operation, the cup was removed because other structures had grown out of proportion There are some doubts as to whether the joint resulting from cup arthroplasty would be sufficiently durable to justify this operation in young subjects (Pridie)



Fig. 116 The same case as in Fig 115 two years after *open* reduction without reaming out the acetabulum. Capsular adhesions between the head and ilium were found at operation. Perfect functional result on both sides but showing shallow sockets.

Our own material on open reduction is not sufficient to permit any final evaluation We have personally operated upon quite a number of patients, but have been unable to follow them up owing to external circumstances So far as our observations could be carried out some of our experiences are reflected in Figures 115 116, 117 and 118

In reviewing the reports of these various authors, it can be seen that the results of open reduction have greatly improved since the early period and that reductions are possible by open operation that could not have been accomplished by non surgical measures. However, the statistics are not sufficiently comprehensive to justify any general conclusion The results reported in recent series reveal that although good functional results may be attained in many cases (Fig 115 and 116) only too fre



Fig 117 Roentgenogram of a girl seven years of age, showing dislocation of the left hip before treatment.

quently they fail to fulfill expectations Many difficulties during reduction, such as shortening of the limb, and disproportion between the size of the head and that of the socket, as well as complications in the postoperative course, such as Perthes disease and coxa vara, are the same as in closed reduction, and many cases, although reduced and stable, have a marked tendency to contracture and considerable limitation of motion (Fig 117 and 118)

C. INDICATIONS

Open reduction being now a well established procedure, an effort must be made to determine which cases should be subjected to open reduction and which to closed reduction Regarding this point, the views of the majority of authors are still divergent. Whereas some, like Galloway, Kidner and Leveuf recommend primary open reduction even in very young children, others



Fig 118 The same case as in Fig 117 one year after *open* reduction accomplished by the reaming out method. Note the evidence of ankylosis and flexion adduction contracture.

including Putti, Bankart Campbell, Steindler Gill Albert Lorenz and Severin, are of the opinion that closed reduction is preferable in young children and that open reduction is indicated only in cases in which closed reduction has failed. We personally do not believe that every C D H can be reduced by closed manipulation nor that every C D H will require open operation

A critical evaluation of the pros and cons for such diametrically opposed conceptions would be beyond the scope of this book Since the field is one in which we have already experienced so many errors, the final word can safely be left to a later appreciation of attainable and desirable results. Until such time the surgeon must be guided by his own judgment as to the proper course to pursue. No dogmatic stand can be taken and clinical experience must be the determining factor It is only thus that we can hope to attain a truly rational treatment for C D H

Admitting the possibility of varying indications in special cases, the following suggestions are offered

1 In children under three years of age with typical C D H, closed reduction is the method of choice The single exception to this rule is found in the rare cases of interposition of the lower leaf of the capsule (p 172) In the great majority of cases, however, there is no such obstacle to justify surgical intervention.

2 In children of three to six years of age, in unilateral cases, and of five years of age in bilateral cases open reduction is indicated if closed reduction has failed There is no other way to combat the obstacles which prevent cure in these cases than by open operation. However we feel that at least *one* primary attempt at closed reduction should be made There can be no doubt that open reduction is considerably complicated owing to the adhesions that form in repeatedly unsuccessfully reduced cases, or after prolonged retention in malposition But it is hard to understand that a *single* previous attempt at closed reduction under proper precautions, will jeopardize the result of an eventually required open reduction. We would rather be inclined to assume that when open operation following unsuccessful closed reduction reveals gross anatomic changes, the latter have been present *earlier*, and were in themselves the cause of failure of the closed reduction. The question as to which cases in this age group should be subjected *primarily* to open reduction is difficult to answer The clinical findings and routine roentgenograms will frequently be of little help in making the decision The further development of *arthography* (p 144) however opens up new prospects in this direction If it reveals marked hourglass constriction of the capsule, primary open reduction may be justifiable

3 In cases of redislocation occurring at the end of the period of immobilization, when the patient begins to walk open reduction is preferable to a repeated attempt at manipulation As a rule, we followed the principle of attempting closed reduction only *once* However, in certain cases with roentgenographically demonstrated favorable anatomic conditions, a second attempt might be justified In other cases it might seem wiser to be satisfied with a mediocre result and postpone the final de-

cision to a later period, when the clinical picture and roentgenogram may indicate whether a radical procedure or a palliative reconstructive intervention would seem to offer better chances of success.

4 In all cases beyond the age period when closed reduction might be expected to yield satisfactory results, i e, in children of more than six years of age, open reduction is indicated. That one may here too have to deal with exceptions, has already been mentioned (p 200) Since good results fall off rapidly in patients beyond this age limit, the upper limit for open reduction has been placed at 10 years. This has been the common opinion *of most surgeons (Dickson, Kidner Colonna)*

Special caution is urged in recommending open reduction for *bilateral* cases, owing to the risk of ankylosis, which when it involves both hips, certainly presents a catastrophe. In these cases, operation must be performed first on *one* side, and only after full mobility can be guaranteed, may one proceed to the second side. In patients of more than 10 years, it is best to abstain from radical therapy and to be satisfied with palliative methods.

On the whole, it must be emphasized that open reduction is not an operation for general use, and that the decision to operate must be made only after most painstaking evaluation of all related factors. We believe that closed and open reduction have *both* their legitimate place in the treatment of C D H, and that *the two methods should not devaluate each other* It is only fair however to emphasize the fact that under similar circumstances, closed reduction is the simpler and safer procedure which within certain limits, yields results which *have not been surpassed* by any open method of treatment It must also be admitted that the natural functional adjustment of the hip following closed reduction allows a more complete development than could be attained in any artificially formed joint which as a rule is incompatible with anatomic perfection.

Chapter XIII

RECONSTRUCTION (SHELF) OPERATION

THE RECONSTRUCTIVE METHODS DATE BACK TO A SUGGESTION made by Koenig (1891) Koenig conceived the brilliant idea of preventing the upward gliding of the trochanter on the ilium by construction of a firm, bony ridge on the ilium above the socket. For this purpose, an osteoperiosteal flap was turned down from the ilium in such a manner that it projected over the head of the femur In the beginning this method met with little success. Subsequently, however, osteoplastic reconstruction of the acetabular roof won increasing approval. According to Ridlon, Ferguson (1904) was the first to undertake the osteoplastic operation in America In 1909 Clarke, of London performed an analogous operation Later the method was adopted by Albee, Buka, Soutter, Dickson, Delagenière, Mauclaire, Hallopeau, Lance, Gill, Hey Groves, Lowman, Ghormley, Spitzy, Schede, Roeren, Juvars, Cole, Compere and Phemister, Crego, Haas and others, surely evidence enough of the efficacy of the method Numerous modifications were suggested in order to meet the anatomic and mechanical requirements. The best known modifications are those of Albee, Lance, Hey Groves, Dickson, and Gill.

A TECHNIC

Albee (1915) originally performed the operation in the following manner The greater trochanter was exposed through a lateral incision, then chiseled off and reflected upward together with the muscular insertions. A bony ridge of about four inches in length was then chiseled above the rim of the socket The resulting bony defect was filled with a free graft from the tibia, three inches long, one inch wide, and divided into two parts. Both parts were introduced into the gap, one anterior, the other more posterior so as to aid in the construction of a horizontal acetabular roof They were secured with kangaroo tendons. The capsule was then pleated and the trochanter returned and sutured

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to its original site. The limb was then placed in a plaster cast in 30° abduction, for two to three months, after which movement was gradually permitted

Later (1919), Albee modified this method, cutting out a bone flap about 1½ inches wide, through the outer table of the ilium right above the acetabulum with a single motor saw With the aid of an osteome, the bone flap is turned down over the capsule of the joint. With a small single saw, a rectangular block of bone of the same width, is then cut out from the outer table of the ilium, a short distance above the plate already removed *This block of bone is completely detached and is placed* as a strut between the newly formed roof and the ilium It is secured by one or two kangaroo tendon *sutures placed in the drill* holes.

Lance (1925) described the following technic for plastic reconstruction of the acetabular vault The dislocation is reduced and the patient is placed on the operating table in the classic Lorenz primary position. An angular cutaneous incision is made with one branch proceeding from the anterior iliac spine backward along the crest of the anterior *third of the ilium The other* branch of the incision extends downward from the iliac spine between the tensor fasciae and the sartorius. The sartorius and rectus are retracted forward, while the tensor fasciae and the anterior portion of the gluteus medius are sharply dissected from the ilium and reflected downward, thus exposing the easily recognizable joint capsule. A bone flap is then cut with a hollow chisel at the upper margin of the capsule by inclining the chisel 45° downward and inward This flap surrounds the capsular *margin* in the form of a semi-circle After deepening the groove made by the chisel, the bone flap is then reflected downward concentrically toward the head Thin osteoperiosteal flaps are inserted in the bony gap thus formed between the bone flap and ilium. These flaps are taken from the tibia and are wedged solidly against each other No special fixation of these *fragments* is necessary as a rule. The muscles are then replaced and sutured with catgut. A plaster cast from the thorax to the ankle is then applied in the Lorenz primary position of 90 abduction and 90°

flexion. The cast is left in situ for one month after which exercises and massage are instituted.

Hey Groves (1927) proceeds in a similar manner with the exception that to fill the gap between the ilium and the reconstructed acetabular roof he removes a crescentic plate from the posterior part of the dorsum ilii including the outer table and cancellous bone. The crescentic plate is placed over the gap and is fixed in place by a pair of ivory pegs driven through it into the ilium

Dickson (1932) was satisfied with pulling the head down to a position opposite the upper rim of the true acetabulum The reflected flap consisted chiefly of the false acetabulum and was therefore lined with fibrous tissue which was smooth and somewhat resembled normal capsular structure This lining may, to some degree, prevent the formation of adhesions and ankylosis. The space between the flap and the side of the ilium was filled with bone chips from the ilium

Gill's technic has already been described (p 262)

Hass employs the following method The patient is placed upon the fracture table in the lateral rotation which renders the side to be operated on easily accessible Both limbs are under traction and in 45° abduction and slight inward rotation The approach to the hip joint is made through a Smith-Petersen incision, in the same manner as for open reduction (p 264) The entire muscle flap is detached subperiosteally from the ilium, thus exposing the original acetabular rim, and completely denuding the false socket A sharp chisel, one inch wide, is then applied to the ilium just above the attachment of the superior leaf of the capsule, and a rectangular bone flap, 1¼ inches wide, is cut from the outer table of the ilium, above the acetabular margin (Fig 119) The bone flap is then carefully leveled down over the head of the femur, leaving the articular cartilage intact. This step is the most important one in the whole procedure It is imperative that an adequately projecting ledge be formed over the head. A rectangular bone plate, one inch wide and two inches long, is removed from the iliac crest and outer table of the ilium This is wedged firmly in between the ilium and bone flap by

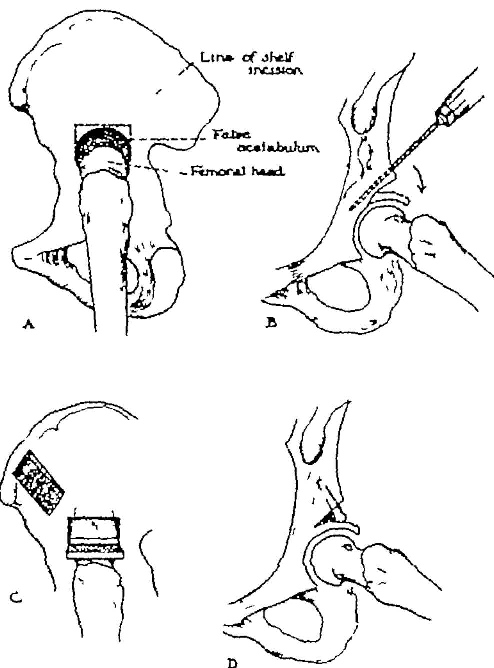


Fig. 119 *Shelf* operation (*Hass* method) A The hip is exposed and a rectangular bone flap is cut from the outer table of the ilium above the acetabular margin. B. The flap of bone is turned down over the head of the femur C. A rectangular bone plate is removed from the iliac crest and outer table of the ilium and is wedged firmly in between the ilium and the bone flap D Lateral view after the operation is completed.

first digging out the cancellous bone of the ilium, and then applying a couple of hammer strokes to the bone plate This holds the shelf firmly and no extra fixation is necessary If the bone plate is accurately placed in position above the shelf, it will be strong enough to hold the shelf in position The vacant space between the bone plate and the ilium is filled with chips of spongiosa from the ilium Once the position has been accurately secured, muscles are replaced and sutured to their former origin The gluteal muscles are more easily sutured to the lateral abdominal muscles, which bulge over the crest.

A plaster spica is then applied to the limb in abduction of 45°, followed by adhesive moleskin traction on the leg for about six weeks, to prevent any undue pressure by the head on the newly formed roof After six weeks, the child may be allowed to walk with crutches, but full weight-bearing on the operated leg is not permitted until six months after operation As a rule, after three months, the bony parts of the shelf will have united, and after six months, a solid arched block is formed over the head

The similarity of the various shelf operations is obvious. *The principle involved is always the same, namely, to correct the* acetabular obliquity by reflecting the roof downward, and maintaining this in the correct position, so that it will permanently resist the upward thrust of the femoral head on weight-bearing.

We feel that no matter what method is used, the following considerations should be observed

1 The femoral head must first be perfectly reduced and *centrally* placed in the primary acetabulum Excentric position will not restore normal gait and may lead to osteoarthritis and pain

2 The shelf should be constructed as *close as possible to the original acetabular margin* A shelf constructed higher up on the ilium, at a pathological site, as recommended by Délangiere, Mauclaire and others, may prevent further upward sliding of the head, but will not correct the deformity or cure the limp

3 The shelf should be constructed from *acetabular tissue,* and a bone graft used only to maintain the shelf in position.

4 The operation must be entirely *extra-articular,* above the

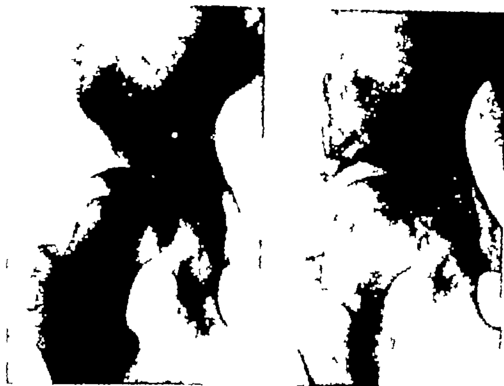


Fig 120 Congenital dislocation of the right hip in a girl 12 years of age. Closed reduction was performed at the age of three. There is a marked limp after prolonged walking and fatigue. Note the flattening of the acetabular roof and slight subluxation.

Fig 121 The same case as in Fig 120 six months after shelf operation without opening the joint. A massive bone block has been formed over the femoral head. Patient has an excellent functional result.

attachment of the superior leaf of the capsule, leaving the articular cartilage intact, in order to prevent stiffness and ankylosis.

5 The bone shelf must be *self stabilizing* and sufficiently *strong* to prevent breaking down under weight bearing

6 It must be turned *obliquely* downward to prevent upward sliding of the head

7 The shelf should be maintained in position by immobilization until it is *consolidated*

8 The shelf operation should not be undertaken *until the child reaches the age of six years*, since prior to this age results may prove a failure owing to absorption of the shelf



Fig 122 Congenital dislocation of the left hip in a girl six years of age, with marked displacement *(luxatio iliaca)* The femoral head was brought down by a preliminary skeletal traction and open reduction was performed without reaming out the acetabulum. The reduction was combined with a shelf procedure

Fig. 123 Roentgenogram of the same case as in Fig. 121 three months after the operation shows perfect position of the head and shelf

B RESULTS

An evaluation of the results of the shelf operation presents a confusing problem because of the variety of material, differences in the age of the patients and in the technic employed In some cases results have not been too favorable.

Lance (1925) was the first to report end-results of the shelf operation. His material comprised 18 cases, re-examined more than 18 months after operation On the whole, his results were quite satisfactory

Spitzy (1934) reported 45 cases operated on by his special technic, using for the shelf, a tibial bone graft hammered in

above the head of the femur without turning down the roof of the acetabulum He obtained excellent results, although a thorough re-examination appears to have been omitted.

F Schede (1935), who employed both Spitzy's and Lance's technic, with preference for the latter, reports a series of 35 cases, in all of which he obtained good function and relief from symptoms, except in one bilateral case. Redislocation did not occur in any case. Also in his later cases, following improvement in his technic, no permanent stiffness developed

Dickson (1935) has performed the shelf operation in 28 dislocated hips with satisfactory results in 82 2 per cent, improvement in 7.7 per cent, and failures in 10 1 per cent. The youngest patient operated on was nine years, the oldest 46 years.

Howorth's statistics, of the same year, included 35 hips, followed up from one to nine years after operation The age of the patients varied from two and one-half to 26 years. In nearly all of his cases the limp persisted but as a rule stability was greatly improved and there was no pain or fatigue

Gill's report (1935) is based on his experience in shelf operations on 125 cases of C D H Fifteen patients were operated upon, without opening the capsule. In all of these, re-examination showed normal motion painless, stable hips, and no instance of redislocation In 30 cases, in which the operation included opening of the capsule, re examination showed satisfactory motion adequate for all ordinary functions of the hip In this series, too the hips remained stable and painless Gill makes no claim of *perfect functional results in old high dislocations,* in which the head cannot be brought down to the level of the original socket He believes that if open reduction is necessary in any case, it is better to construct the shelf and reflect the roof at once This requires but little more time, and gives a better guarantee of a stable hip

Ober (1935) presents his results in a series of 20 shelf operations for C D H The youngest patient was three years and 10 months of age and the oldest 11 years. In one half of the cases treated the shelf partially or wholly disappeared The reason for the disappearance of *the shelf in so many* cases was attributed mainly to a poorly constructed shelf, or a shelf not constructed

of acetabular tissue, and failure to pull the femoral head down to its normal position.

Therkelsen (1938) operated on 61 patients, including 68 hips, in the period from 1927 to 1936 at the Clinic of Copenhagen In 55 patients, with 60 operated hips, the follow-up period ranged from one to nine years, or an average of three and one-quarter years. The age of the patients at the time of the operation was from two and one half to 37 years The technic corresponded to that used by Lance and somewhat modified by Mathieu Good results were obtained in 33 cases, and improvement in 14 cases. In both of these groups, the patients seemed to have derived great benefits from the operation In 13 cases, the condition remained unchanged, and in a few was even "exacerbated" In no case did the operation completely obviate the limp and Trendelenburg's sign Nevertheless, the operation evidently did relieve pain, and improved the stability of the joint, thus greatly increasing the patient's endurance for walking and other exercises

Still less encouraging are the results reported by A. R. Smith (1937) and later by Ponseti (1946) from the Steindler Clinic. Smith's report would seem to indicate that the shelf operation leads to marked amelioration of symptoms, especially in older children with unilateral dislocation. However, in the younger children, with bilateral dislocation, the functional results of the shelf operation are very poor, and some of the patients may even require secondary surgical procedures on the shelf side to attain stability Ponseti reports a series of 77 dislocated hips treated by the shelf operation The average follow-up period was seven years, with a minimum of four years, and a maximum of 20 years. Of the 42 shelf operations, with the femoral head in the primary acetabulum, a normal hip joint developed in only one, whereas in five of these cases the result was a moderate deformity of the hip One hip, in a 15 year old patient, became ankylotic following forced reduction and a shelf operation In the remaining 35 hips, the femoral head became displaced after operation Frequently, however, the femoral head finally became stabilized in a secondary acetabulum, situated somewhat above the pri-

mary acetabulum and away from the line of gravity From the functional point of view the limp disappeared in only eight patients The remaining 34 patients continued to limp some developing limitation of motion, and a few had pain

Ponseti draws special attention to the fact, earlier emphasized by other writers such as Ober Therkelsen and others, that many patients treated for dislocations or subluxations of the hip by the shelf operation, with the femoral head in a secondary acetabulum, continue to limp even though the shelf was strong and well built They believe the cause to lie in the pathomechanics of the hip joint following the shelf operation Ponseti noticed that in those cases, in which the shelf was built at the upper end of the sloping acetabular roof, the femoral head in walking, came under the shelf at a somewhat higher level than the normal acetabulum, and too far distant from the line of gravity The hip muscles are not strong enough to neutralize the rotary effect produced by gravity upon a hip with the femoral head subluxated under the shelf, and in consequence the Trendelenburg sign becomes positive, and the patient limps. From these observations, Ponseti concluded that the aim of treatment for dislocation of the hip is not the construction of a big shelf but the *exact and permanent centralization of the femoral head in the* acetabular cavity When reduction of the femoral head cannot be maintained in the primary acetabulum, the shelved hip will always be defective mechanically

In analyzing the results of the shelf operation, as presented above, it must be kept in mind that in these patients we are dealing with cases in which neither simple closed reduction nor open reduction alone, could be expected to yield successful results. In other words, these cases belonged to a generally less favorable class of older patients, in whom a complete anatomic restoration was not to be expected a priori It is not to be wondered at, therefore, that in these cases, even after a successful shelf operation, there should remain some disproportion of the joint bodies, with all the disadvantages this involves. In fact one would almost be forced to reckon with the possibility of postoperative deformities in later life. In truth, the shelf operation contributes less to rigidity of the joint than the reaming out

of the acetabulum, and nevertheless is no protection against postoperative deformities of the head The positive value of the shelf operation lies primarily in restoration of stability and prevention of reluxation In this light, the shelf operation may be stated to restore practical and lasting security in a good percentage of cases (Figures 120 121, 122, and 123)

According to numerous observations, in the majority of cases, the shelf remains intact and forms a solid block above the head, well suited to give adequate support to the head This process usually takes about six months to be completed In some cases, the edge of the shelf was fractured, and in many cases the shelf was absorbed, so that after a short time it could no longer be seen in the roentgenogram This happens, however, only when the operation, in mistaken eagerness to help the patient, is undertaken too early, i e., before the sixth year of life. In some cases, the hip may be satisfactorily stabilized, even though the roentgenogram does not clearly show the bony structure Many writers consider one of the disadvantages of this operation to be a limitation of abduction, but we have seen no such result in our material Frequently the impression is gained that many of the poor results are attributable to poor technic, and that some improvement in the operative technic and after-care would yield better and more uniform results

One of the important factors in this hoped for progress will consist in a more careful selection of cases for the operation

C. INDICATIONS

The shelf operation was first used in cases showing a tendency toward reluxation and in cases of subluxation Its highly constructive basis has resulted in further extension of the indications for its application According to our present conceptions, the shelf operation is indicated

1 In all cases following *closed reduction, in which four years after reduction, there is still no adequate stability of shape of the acetabular roof*

2 In all cases of *subluxation after the sixth year of life* In these cases, the shelf operation offers the only solution.

3 In all cases of *open reduction, in which the acetabulum is found too shallow,* the shelf operation is performed as a simul-

taneous procedure in order to secure immediate stability of the joint. If, however, open reduction was performed in a child under 6 years of age, then the shelf operation should be postponed until the child has reached the age of 6 or 7 years because of possible absorption.

4 The procedure is applicable in all hips showing *definite changes after puberty*, which might lead to slipping of the head under weight bearing, and which may cause pain or an undue degree of limp and disability

An upper age limit cannot be determined At any rate, the shelf operation may be performed in advanced age without ill effects.

In conclusion, we may state that the shelf operation has justified its use, and has been extended to the treatment of certain cases as a complementary operation to closed and open reduction. On the basis of our observations, we have formed the opinion that with a careful selection of cases and an exact technic, the operation will relieve the patient from pain and may improve the stability and statics of gait

Chapter XIV

PALLIATIVE PROCEDURES

PALLIATIVE PROCEDURES ARE NOT EMPLOYED IN THE HOPE OF restoring the joint to a normal condition, but only with a view toward improving function and preventing complications.

Palliative treatment comes under consideration for two groups of patients

1 For patients who have never had their hips reduced, and who have so far exceeded the age limit that an anatomic restoration is no longer to be hoped for

2 For patients who have been subjected to closed reduction, but have redislocated, and owing to their unfavorable anatomic condition (too much shortening), appear unsuitable for open reduction.

The purpose of palliative treatment in these cases is to alleviate the symptoms present, to improve gait capacity, and to prevent the development of contractures.

For this purpose, we have available, to begin with, a series of aids, which we will designate as *mechanical palliative aids*

The oldest apparatus are those for relief of weight-bearing It cannot be denied that the difficulties associated with anterior subluxation may be effectively counteracted by such apparatus. But in more severe cases such measures fail In addition to the absolute uncertainty of their effect, they may lead to general atrophy of the limb because during the years when the apparatus is worn, the limb is completely deprived of all function

The same purpose is served by a variety of *girdles*, devised to support the trochanter from above Such girdles have been constructed by Heusner, Schede, Lange, Dreesmann, and others Hessing has devised a girdle, which from a technical point of view could hardly be surpassed (Fig 124) It consists, in principle, of a pelvic girdle and a metal band which surrounds the trochanter from above, and presses it against an adjustable ischioring Unfortunately even this girdle will after prolonged use,



Fig 124 Hessing girdle for palliative treatment of old irreducible dislocations of the hip

damage the functionally important pelviotrochanteric muscles At present, this apparatus is no longer used In cases of inoperable dislocations, we employ the same simple girdle as for after-treatment of cases in which reduction is not completely certain, to prevent a tendency to redislocation (see Fig 85)

The problem can be met much more efficiently by suitable *palliative, conservative and operative measures* Among these a non surgical method namely forward transposition of the femoral head is worthy of special mention

A ANTERIOR TRANSPOSITION OF THE FEMORAL HEAD

This is a primary forward transposition of the femoral head toward the iliac spine, with simultan... of the almost

invariably present flexor-adduction contracture of the hip Practically, this coincides with the so-called "*inversion*" of Lorenz, which consists mainly of changing the usually present flexion-adduction contracture position to its opposite, which will in itself, insure considerable functional improvement.

The operation begins with a subcutaneous tenotomy of the adductors and changing the position of the hip into moderate *abduction*, thus permitting a better approximation of the head to the lateral pelvic wall The second act consists in *hyperextension* of the joint While an assistant fixes the pelvis by maximal flexion of the other hip, the flexion contracture of the hip is gradually obliterated by rhythmical tractions. If the soft tissues on the flexor aspect of the joint will not yield, a subcutaneous fascio-myotomy of the subspinal soft parts, as extensive as possible, is performed at once, thus permitting adjustment of the thigh a little posterior to the frontal plane The final forward transposition of the mobilized femoral head to the iliac spine is accomplished in a final manipulation by maximal hyperextension combined with abduction to about 30° The limb is then immobilized in a spica cast, extending from the nipples to just above the ankle, with slight flexion of the knee so as to maintain position of inward rotation First attempts at walking may as a rule be made as early as two weeks after operation. In unilateral cases, the foot on the normal side is raised by interpolation of a half-inch sole. After 10 weeks, the cast is removed. The gymnastic after treatment, which is instituted immediately following removal of the cast, includes active and passive hyperextension and abduction exercises, besides energetic massage of the pelvi-trochanteric muscles.

The immediate effect of this procedure is to abolish the contracture position and to diminish the spinal lordosis. The functional improvement becomes quickly manifest in a marked diminution of limping, relief from pain, and increased endurance in walking This functional improvement is attributable to the improved support given to the anterior and laterally inclined pelvis by the forward transported head A certain degree of motility was retained in all cases treated by this method One

disadvantage of the method is the danger of recurrence, which can be held in check by application of the luxation girdle mentioned above.

Haberler reports a series of 21 cases from the Vienna Clinic, treated by transposition (inversion) The follow up period ranged from one to 11 years. In this group of cases, very good results were obtained in 5 cases, good results in 7 cases, improvement in three cases, and no result in 5 cases.

Anterior transposition is indicated when both closed and open reduction have failed and is usually performed after 10 years of age. *Occasionally it may also be indicated in younger* children between 6 and 10 years of age when for one reason or another, open operation appears to be contraindicated As a rule the older cases of bilateral luxation with a marked typical contracture position, are best suited for this procedure.

This method is applicable only to hips with intermediary dislocation (luxatio supracotyloidea et iliaca) with a shortening of not more than one or two inches Cases with more marked shortening and iliac dislocation respond much better to subtrochanteric osteotomy, as described below

B SUBTROCHANTERIC OSTEOTOMIES

For old irreducible cases of C D H, subtrochanteric osteotomy has become a well established procedure. It was first suggested by Kirmisson, in 1894 The question as to how and at what site the pelvis was to be supported was not discussed however Kirmission had in mind only a correction of the adduction contracture *almost constantly associated with old dislocations. Subsequently,* subtrochanteric osteotomies were performed also by Hoffa Tilanus, Ludloff, Drehmann Albanese, and in particular by Froehlich. *Lorenz (1919) was the first to define the purpose* of this operation, i e, the provision of a *bony support for the pelvis at a physiological site,* namely the socket. The weight of the body instead of being suspended by the ligaments and capsule *will rest* upon an upper end of the femur To attain this end he performed an osteotomy at the level of the socket and displaced the osteotomized upper femoral end of the distal fragment into the acetabulum The two ends of the fragments eventually unite and

the proximal end of the femur is thus divided into a two-pronged fork (bifurcation), the lateral prong consisting of the head, neck and trochanter, and the medial prong leaning against the site of the acetabulum. In this way, the femur describes a detour over the socket, and the weight of the body, instead of being merely suspended on the femur by the capsule and ligaments, rests firmly upon the shaft of the femur at the site of the original acetabulum.

This idea was first put into effect in 1917, when Lorenz, in attempting reduction in an old luxation, accidentally inflicted a subtrochanteric fracture. He left the central fragment in situ and introduced the upper end of the distal fragment instead of the femoral head into the socket (p 201) The result of this operation was satisfactory, insofar as the previously completely destroyed weight-bearing capacity of the dislocated hip was restored, and the patient, although limping slightly, was able to walk without pain or fatigue. Later, Lorenz utilized this method in numerous cases of irreducible dislocation of the hip

In the interim, v Baeyer (1918), quite independently of Lorenz, had likewise attempted to support the pelvis by performing a subtrochanteric osteotomy He placed special emphasis however, upon the effect of the stretched pelvi-trochanteric muscles (gluteus medius and minimus)

Whereas these two methods, the Lorenz bifurcation and v Baeyer's osteotomy, were based on the same principle of direct pelvic support at the site of the acetabulum, this did not form the basis for the later method of a 'low' subtrochanteric osteotomy at the level of the ischial tuberosity, suggested by Schanz (1922) The purpose of this method was to obviate the Trendelenburg phenomenon by application of the adducted upper fragment to the side of the pelvis, thus providing a *flat* support of the pelvis by the central fragment

During the years that followed, subtrochanteric osteotomies were performed by many surgeons (Hahn, Loeffler, Reich, Wullstein, Natzler, Nové Josserand, Froehlich, Delitala, and others) There appears to be some confusion in terminology however, in the literature, with regard to "*high*" and "*low*" subtrochanteric

osteotomy, so that an accurate description of these two methods seems justified

Lorenz Bifurcation Operation The patient is placed as is customary for subtrochanteric osteotomy on his normal side A lateral skin incision is made, extending four inches downward from the protuberance of the greater trochanter The fascia lata and the musculature are divided in the direction of their fibers. After the periosteum has been split longitudinally and removed the bones are held in suitable retractors to avoid injury to the soft parts The site corresponding to the center of the floor of the socket, as demonstrated in the roentgenogram is then marked, and a broad, sharp chisel is applied to the external surface of the femur The femur is divided transversely Then follows the displacement of the distal fragment into the socket. While holding the limb in abduction with one hand the proximal end of the distal fragment is pressed firmly into the socket with the thumb and index finger of the other hand which have been introduced into the wound After making sure that the fragment is solidly fitted into the socket, the wound is closed The whole operation is completely extra articular and is technically simple. In cases with marked adduction contracture tenotomy of the adductors is necessary in order to prevent postoperative erection of the fragments or disturbance of the abduction angle designed and desired by the operator

A plaster cast is applied in moderate abduction slight extension and slight inward rotation extending from the nipple to the toes In order to avoid unnecessary muscle tension and to maintain the inward rotation the knee is placed in slight flexion in the cast It is, of course, very important to maintain the position unchanged during application of the cast and to mould the cast very carefully to fit about the pelvis and at the bend below the hip After six weeks the patient is allowed up on crutches. Three months after the operation, the cast is removed in toto

Lorenz chose a simple *transverse* osteotomy in order to keep the upper end of the femoral shaft as horizontal as possible and thus provide the socket with a level supporting surface The author has suggested osteotomy in an *oblique frontal plane* in

order to obtain the most extensive contact possible of the cut bony surfaces, and to prevent flexion of the proximal end of the distal fragment (Fig 125A and B)

Schanz osteotomy This osteotomy is performed at the level of the inferior margin of the ischium identified by a mark

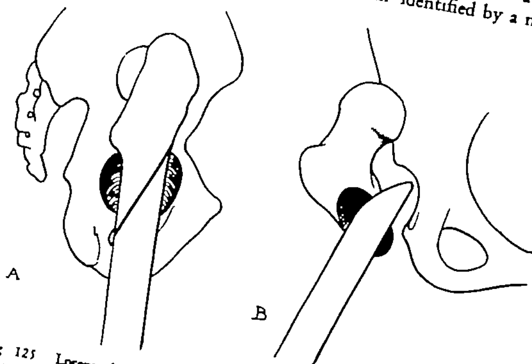


Fig 125 Lorenz bifurcation operation. A Lateral view shows an oblique subtrochanteric osteotomy opposite the acetabulum. B Frontal view shows displacement of the proximal end of the distal fragment into the acetabulum

on the skin corresponding to the roentgenogram The incision passes between the sartorius and tensor fasciae. Following exposure of the femur above and below the osteotomy line two long drill screws of non-rusting steel are introduced into the bone and left protruding from the wound. Only then is the bone cut through obliquely Then the muscles, fascia and skin are completely closed around these screws and the cast is applied The oblique position of the two screws indicates accurately the angle of the break. They are included in the plaster cast, and are removed after six weeks (Fig 126A and B)

The "high" subtrochanteric osteotomy is identical with the methods of Lorenz and V Baeyer whereas the "low" subtrochanteric osteotomy corresponds to the Schanz method

One objection offered to the Schanz method, is that this osteotomy is *too low*, and thus carries with it all the disadvant

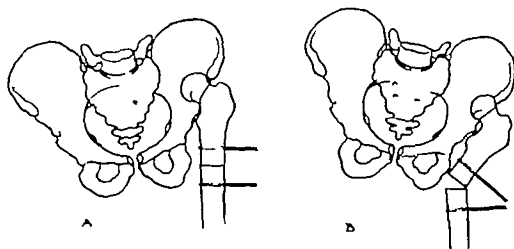


Fig 126 Schanz osteotomy at the level of the tuberosity of the ischium to obviate Trendelenburg's phenomenon A Before operation with screws to control angulation of the fragments. B. After operation.

ages associated with such a low abduction break in the thigh. Aside from the unfavorable torsion factor, thus involved, abduction at this site has both a functionally and otherwise disturbing effect. Those patients whom we have had opportunity of examining following a Schanz osteotomy, have shown excessive genu valgum necessitating in some instances, a retrograde osteotomy *in the hope of restoring a condition at least as favorable as that* present before the operation. The principal objection to this method however, is the fact that the pelvic support in a Schanz osteotomy presents a *gliding surface*, thus rendering the pelvic support imperfect

Numerous objections have, however been voiced also to the Lorenz bifurcation They deal chiefly with the pains and limited range of motion, which seem to follow this operation Milch assumes that the bony spike formed by the upper end of the osteotomized shaft, and directed against the acetabulum, is the cause of the pain referred to, and that the spike itself imposes

the necessity of greater abduction and the assurance of limitation of motion. He concludes that in obstinate cases the point of the spike should be resected. Gaenslen has drawn attention to the fact that the shortening is greater in the Lorenz bifurcation than in a Schanz osteotomy, owing to the overlapping required for introduction of the inner prong into the socket, and for this reason prefers the Schanz osteotomy

These objections to the Lorenz bifurcation which were expressed also earlier by other writers, such as Schulte, Hackenbroch, Mommsen, Brandes, and others, led the present author, already in 1924, to modify this method, by utilizing the *lesser trochanter* as a point of support by displacing the lesser trochanter into the acetabulum, and transposing the osteotomized shaft of the femur beneath the lower end of the upper fragment. The lesser trochanter, because of its round, smooth surface, offers a most suitable substitute for the femoral head, and the method presented will not only restore stability of the hip, but also insures freedom from pain and adequate mobility

The initial inspiration for this method occurred while observing a case in which spontaneous pelvic support by the lesser trochanter had developed In a woman, aged 42 years, with an untreated bilateral congenital dislocation of the hips, roentgenograms revealed that on both sides, the lesser trochanters articulated with the corresponding acetabula, to form an excellent pelvic support (see Fig 26) This woman had no complaints, whatsoever, except some limitation of adduction It was this case that suggested the systematic use of the lesser trochanter as a point of support in all cases of old, irreducible C D H The lesser trochanter method was later advocated by Kreuz, and was finally adopted by Lance, Jr However Lance placed greater emphasis on the adduction of the proximal fragment, than on displacement of the lesser trochanter into the acetabulum, and recommended a special instrument which he called a 'davier-tracteur' for the purpose of obtaining better contact of the proximal fragment with the lateral wall of the pelvis

Hass osteotomy This operation consists of two parts i.e 1 a locking osteotomy beneath the lesser trochanter, and,

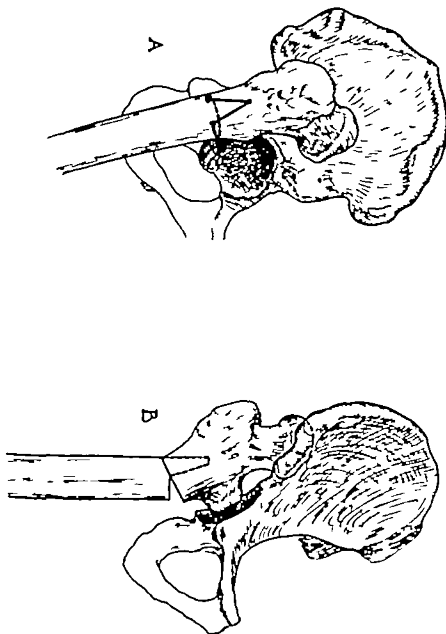


Fig 127 *Hass* osteotomy for irreducible dislocations of the hip A Lateral view shows locking osteotomy by forming a triangular slot and plug in the outer surface of the femoral shaft beneath the lesser trochanter B Anterior view shows the divided femur and the *lesser trochanter* displaced into the acetabulum.

2 displacement of the lesser trochanter into the acetabulum The patient is placed on the normal side, and fixed in this position by sand bags. Through a longitudinal incision of four or five inches below the greater trochanter, the lateral subtrochanteric area of the femur is exposed The incision is carried down through the periosteum, which is stripped and retracted with the muscles. Following this, a *locking* osteotomy is carried out just below the lesser trochanter, by forming a triangular slot and plug on the outer surface of the femur to prevent sliding or overlapping of the fragments, and to insure solid bony union at the site of the osteotomy To facilitate this procedure, drill holes are placed outlining the corners of the triangle and the line of division of the shaft. Osteotomy is then performed by cutting the triangular plug and dividing the rest of the shaft transversely with a narrow osteotome (Fig 127)

After the osteotomy is completed, and while the leg is gently abducted with one hand, the thumb of the other hand is pressed against the lower end of the upper fragment. By this means, the lesser trochanter is directed toward the acetabulum No slipping or overlapping of the fragments is possible, since both fragments are interlocked The technic is the same for bilateral cases. Recently, in order to shorten the period of hospitalization, the entire bilateral operation has been completed in *one stage*, the patient being placed in the supine position with a sandbag beneath the sacrum, to render both sides easily accessible

The postoperative abduction angle should not exceed 40° to 50° in unilateral cases, and should be limited to 30° or 40° in bilateral cases. There is, furthermore, a slight inward rotation of about 10° necessary, to compensate for the postoperative tendency toward outward rotation Since the dislocated head is usually also posterior the osteotomy angle is also directed *posteriorly* to a certain degree. Thus the fragments form an angle opening outward and backward The position is checked roentgenographically If not satisfactory, it can be easily corrected The wound is then closed and a long spica, extending from the chest to the toes is applied (Fig 128) In patients over 20 years of age,

preliminary tenotomy of the adductor muscles may be necessary to overcome the contracture frequently associated with old congenital hip dislocations, and to prevent a loss of the abduction angle after operation Eight weeks after the operation, the knee

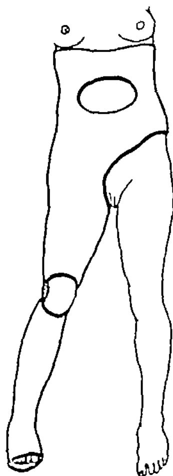


Fig 128 Spica cast after the operation, with knee hinges inserted into the cast.

is released and metal hinges are incorporated in the cast on both sides of the knee so that the joint may be flexed Walking is then gradually resumed with the aid of crutches. As a rule, bony union at the site of osteotomy is sufficiently solid after three months to permit removal of the cast and weight bearing

The method described above relies for its success largely upon the fact that the new point of support is established at the



Fig 129 Congenital dislocation of the right hip (*luxatio iliaca*) in a woman aged 28 years.

Fig. 130 The same case as in Fig 129 eight years after the operation. The femur had been drawn down by preliminary skeletal traction and after a lock ing osteotomy below the lesser trochanter the latter had been displaced into the acetabulum. The functional result was perfect.

acetabulum, and the weight-bearing thrust is shifted from the dislocated and unstable femoral head directly onto the shaft of the femur, via the lesser trochanter The operative technic differs from that in the typical Lorenz bifurcation in several respects. Whereas, in the latter procedure, the *upper* end of the distal fragment is displaced into the socket, in this method the *lesser trochanter* as part of the *proximal* fragment, is displaced into the acetabulum. At the same time, the upper end of the osteotomized shaft is brought *under* the proximal fragment. In this manner, the lesser trochanter acts as a hypomochlion in the acetabulum, and no spike is formed and directed against the anterolateral wall of the ischium, which might give rise to pain and other disturbances



Fig 131 Bilateral congenital dislocation in a girl aged 14 years *(luxatio supra cotyloidea et iliaca)* The patient complained of severe pain and had marked disability

Fig 132 The same case as in Fig 131 10 years after the operation There is good pelvic support by the lesser trochanter on both sides. The patient is free *from pain walks without a limp and has full range of motion except for* slight limitation of adduction. Note the increased density of the shaft indicating that weight bearing takes place through the acetabulum to the shaft

The *adduction* of the *proximal* fragment is an essential factor, as is likewise the tension of the pelvitrochanteric muscles resulting from the downward tilt of the greater trochanter The most important part of the procedure, however, is the *abduction* of the *distal* fragment, by means of which, the acetabulum receives the thrust, even though their is little left of the original acetabulum The *postoperative angle* is considerably less than that required in the bifurcation operation—in unilateral cases, no more than 40° to 50° This degree of abduction in unilateral cases can readily be compensated for by the pelvic tilt, and will also compensate to a considerable degree for shortening of the leg (Figs. 129 and 130) In bilateral cases, however, special caution is necessary in abduction owing to the possible failure of bringing the limbs into parallel alignment. For this reason abduction should not exceed 30°-40° in bilateral cases. On the other hand, in bilateral cases, the pelvis is held in check on both sides by the lesser trochanter which exerts a sort of brake action, and therefore less abduction is required than in unilateral cases (Figs. 131 and 132) Special difficulty may be encountered in bilateral cases, in which the dislocation is unequal, as, for example, in a case with supracotyloid position on one side, and iliac position on the other side. As a rule, the further removed the lesser trochanter is from the acetabulum, the more abduction will be required in order to bring the lesser trochanter closer to the center of gravity Naturally, besides the abduction angle, one has also to consider the anterior angulation, which is more acute on the side of the iliacal displacement than on the side of the supracotyloid position. In any case, it is the author's opinion that the degree of angulation is the most delicate part of the procedure, and should be carefully calculated before the operation, and roentgenographically checked before closure.

In recent times, internal fixation by means of a Moore-Blount blade-plate has been used in order to secure angulation and to avoid a plaster cast (Figs. 133 and 134) The only disadvantage of this method was the fact that in the presence of anteversion of the femoral head, the blade plate could be bent in only one



Fig 133 Irreducible congenital dislocation of the left hip in a man 35 years of age

Fig 134 The same case as in Figure 133 three months after su osteotomy A Moore Blount blade-plate was used to secure p and to avoid a plaster cast Excellent result

direction In cases of marked anteversion it is to make use of the good old plaster cast

In 1943, the author reported a series of 18 by *this method 16 females and two males,* bilateral dislocations. The age of the patients from 14 to 40 years. In all but or followed up for more than fiv entirely satisfactory in all case appeared the patients were fr sign was negative and the lim *tients had adequate motion* w limited motion before the ope quate range of motion attain

was due to the smooth and rounded surface of the supporting point, as well as to the fact, that the proximal lever of the system — comprising head, neck and trochanter — is relatively short. Slight limitation was observed in adduction only, and this presents practically no handicap for the patient. As a matter of fact, the postoperative degree of mobility depends almost entirely upon what degree of mobility was present prior to operation. If the head was freely movable before intervention, the postoperative mobility should be almost perfect. If, however, the head was fixed in a secondary false acetabulum — as for instance by osteoarthritis — there would, of course, be a marked limitation of mobility after operation.

It is understood, of course, that the indication for any kind of subtrochanteric osteotomy in congenital hip dislocations, depends primarily upon their irreducibility. It is felt that the lesser trochanter method has definite value, and is especially applicable to cases of anterior, lateral or intermediate position (luxatio supracotyloidea and luxatio supracotyloidea et iliaca). In cases such as these, roentgenograms usually reveal a well developed lesser trochanter, situated just opposite or near the acetabulum and practically inviting displacement into the acetabulum. Experience has shown that the lesser trochanter may be used as well in a higher position of the femoral head (luxatio iliaca), after a preliminary period of about two weeks of skeletal traction has drawn the lesser trochanter down to the level of the acetabulum. As a matter of fact, the use of the lesser trochanter is the method applicable in the great majority of all irreducible hip dislocations. However, *to avoid growth disturbances, the operation should not be carried out until the patient reaches the age of puberty.*

It is our belief that subtrochanteric osteotomy will gain in favor as compared with other operative procedures, because of the lesser danger of the operation and of postoperative complications in older cases. From the anatomical point of view, the method does not constitute an ideal procedure, but it is an operation which offers solution of a difficult problem in a satisfactory manner.



Fig 133 Irreducible congenital dislocation of the left hip in a man 35 years of age.

Fig 134 The same case as in Figure 133 three months after subtrochanteric osteotomy A Moore Blount blade plate was used to secure proper angulation and to avoid a plaster cast. Excellent result.

direction. In cases of marked anteversion it is therefore better to make use of the good old plaster cast.

In 1943, the author reported a series of 18 patients treated by this method, 16 females and two males, including four with bilateral dislocations. The age of the patients at operation ranged from 14 to 40 years. In all but one case these patients were followed up for more than five years. The end results were entirely satisfactory in all cases. The pathological lordosis disappeared the patients were free from pain, the Trendelenburg sign was negative, and the limp was scarcely noticeable All patients had adequate motion with the exception of one, who had limited motion before the operation In all likelihood the adequate range of motion attained in these patients postoperatively

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C. ARTHRODESIS

This operation is designed for a group of patients with C D H who are seriously disabled and cannot be relieved by other means. In this connection we would mention first Roser's attempt to produce a rigid, fibrous ankylosis of the joint following resection of the femoral head Here, too, belongs Siraud's suggestion of chiseling off the greater trochanter and fixing it above the femoral head to the os ilium in such a manner as to produce an ankylosis of the three bones. For the sake of completeness, we should also mention Guerin's attempts to bring the ilium and femoral head into direct bony contact by subcutaneous scarification Most recently, Fraenkel has once more recommended arthrodesis, describing it as the best of all palliative procedures in irreducible C D H to assure constantly good end results with freedom from pain. He has used it even in very young individuals between seven and 15 years of age, the average being 12 years. Seven of his 14 patients were girls.

It cannot be denied — presupposing a unilateral affection — that the thought of relieving the patient's symptoms by an arthrodesis seems quite rational Judged from a surgical standpoint, it is doubtless better for the patient to have a hip joint fixed in good position than a movable hip joint, which is painful unstable, and inadequate with a tendency to contracture Any orthopedist who has had any extensive experience in the treatment of tuberculosis of the hip joint is firmly convinced of this principle. Nevertheless it may be difficult to persuade a patient with C D H, which has, of course wholly other prognostic criteria of the advantages of a fixed hip joint, especially in the case of female patients who are still young and in the reproductive age. In our experience these patients cannot reconcile themselves to having a stiff joint and will prefer a movable even though painful joint to one which is rigid For a young woman the handicap of a stiff hip is more than the mere inability to lace her shoe. In our opinion the surgeon who recommends arthrodesis for a young female patient is giving poor advice

Arthrodesis may however be indicated especially in male patients and elderly women in cases where it is desirable to ren

der the patient capable of heavy work This operation, which definitely eliminates any movement of the joint whatsoever, should never be performed unless definite indications can be demonstrated

The procedure consists of an extra- and intra-articular fusion, accomplished by imbedding a massive bone graft between the femoral head and the innominate bone without complete denudation of the joint surfaces, thus shortening the time of operation and reducing shock The joint is exposed by a lateral incision and a wedge-shaped section of bone is excised from the femoral head and acetabular roof, as suggested by Albee The gap is filled with cancellous bone chips. Then an osteoperiosteal bone graft of corresponding length is removed from the outer surface of the greater trochanter and femoral shaft. This bone graft is then turned upside down and is inserted proximally just above the acetabulum in the thick part of the ilium and distal to the femur A long Smith-Petersen nail driven through the neck, head and ilium in addition to the bone fusion, will prove most valuable in securing immediate fixation Nevertheless, it is necessary to apply a double plaster spica for three months The best position is that of 25° of flexion with 5° or 10° abduction and neutral rotation.

We have used this method in a very small series of cases in the age group from 50 to 60 years, and in cases where the femoral head was near the acetabulum We were of the opinion that only *one* indication existed for this operation, i e., disability of sufficient degree to prevent the patient from following any occupation *However, we feel that arthrodesis of the hip should never be the first but always the last method to be tried, and that it is justified only when all other attempts to relieve symptoms with preservation of mobility have failed*

Chapter XV

SUMMARY OF TREATMENT

THE FOLLOWING IS A BRIEF SURVEY OF CERTAIN RULES TO serve as a guide in the management of C D H in special age groups since patients with this affliction are admitted at all ages from infancy to adult life. The treatment cannot, however be based solely upon the age of the patient but must be governed by the special findings in each individual case, i.e anatomical findings, whether the dislocation is unilateral or bilateral, the position of the femoral head and whether the latter is subluxated, supracotyloid or iliacal, a history of previous operations, et. In general, it may be stated, however, that the difficulties increase progressively with the age of the patient and at certain stages of development, require special procedures according to the following age groups

1 In early infancy up to *one year* of age the greatest majority of cases can be cured by simple prophylactic measures alone. Only in cases of marked subluxation and dislocation should reduction and immobilization be performed even below *one year of age* *Early treatment in the modern sense* i e., within the first year of life, is a marked step in advance in the management of C D H

2 In children from *one to three years* of age, closed reduction is still the method of choice, as it has been since the time of its introduction. The elimination of all violence is one of the most important requisites of treatment. Another improvement is the accentuation of the original primary position for retention. We believe that our accentuated flexion abduction position permits a much deeper adjustment of the femoral head into the socket than the internal rotation of the extremity Sufficiently protracted immobilization is also of importance poor end results will be much less common if the reduced hip is held securely in the acetabulum until a thoroughly adequate acetabular roof can be demonstrated roentgenographically Cor

rection of anteversion is advisable when the anteversion is more than 45° However, there is some evidence that spontaneous correction may occur

3 In children from *three to five years in bilateral cases or to six years in unilateral cases,* closed reduction should be attempted, but only with such gentle manipulations as will do no damage to the tissue. Preliminary traction will certainly facilitate reduction and help to prevent traumatization. If closed reduction fails, open reduction should be performed.

4 In children from *five or six to ten years,* open reduction is the generally accepted method With very few exceptions, there is no other choice. Of course all depends upon whether the head can be brought down to the level of the original acetabulum. In cases where the acetabular roof is found too shallow, the open reduction should be combined with an osteoplastic "shelf" operation A shelf operation is also indicated after closed reduction, if four years after reduction the acetabular roof is still insufficient, and there is a tendency to subluxation. If reduction has been performed (closed or open) in children over five or six years of age, and the femoral head retained in forced inner rotation then it might be necessary to carry out a subtrochanteric rotation osteotomy three months later, in order to prevent outward rotation and redislocation

5 Cases *over 10 years of age* This age group includes all neglected and unsuccessful cases, in which the head cannot be replaced into the original acetabulum by any known method In these cases only palliative surgical measures are justifiable, and the best of these methods are anterior transposition of the femoral head and subtrochanteric osteotomy Which of these methods is to be used will depend primarily upon the degree of dislocation and the anatomic conditions For cases of luxatio supracotyloidea with slight shortening, the anterior transposition operation is best suited, but in all other cases subtrochanteric osteotomy is indicated. The author's method of using the lesser trochanter as a point of support in the acetabulum has proved a valuable procedure This operation should be regarded as the routine method for all irreducible cases in patients over 15 years

of age both in unilateral and bilateral cases. An arthrodesis of the hip, which offers the least desirable surgical results, is to be considered only as a last resort in very rare cases in patients from 50 to 60 years of age.

Good judgment must of course be used in selecting any form of treatment and the surgeon in charge should neglect no detail of preoperative and postoperative care.

Chapter XVI

TREATMENT OF THE ATYPICAL CONGENITAL DISLOCATIONS

THE PATHOLOGY, ETIOLOGY, SYMPTOMATOLOGY AND PROGnosis, of teratologic dislocation have already been discussed in their respective chapters together with typical C D H It remains to consider the treatment of these cases

As mentioned earlier the anatomic conditions of the teratologic group differ considerably from those observed in typical dislocation, and for this reason the methods of treatment and the prospects of successful results of treatment differ from those pertaining to typical dislocation

Lorenz flatly pronounces them irreducible and advises against any treatment Gill likewise seems to subscribe to this opinion and makes no attempt to reduce the hips in cases of extreme malformation combined with other congenital deformities

Other writers seem less pessimistic and report isolated successful cures. Thus Joachimsthal reports a case of C D H combined with marked dislocation of the knee joint, which he examined the day after the birth of the infant, and in which he was able to reduce the dislocated knee joint with ease He was likewise able to reduce the hip joint in this case eight days later Bade reports a similar case Joachimsthal was also able to obtain complete cure by closed reduction in a case of C D H combined with spina bifida occulta

Ridlon reports the case of a girl of four years of age, whom Lorenz refused to treat In addition to dislocation of both hips, she had stiff and recurvated knees, talipes equinovarus, clubbed hands, somewhat flexed and stiff elbows, webbed axillae and little movement of the shoulders The hips were replaced, the knees and feet cured, and the hands greatly improved. Another case had a dislocation of the left hip a recurvated left knee and equinovarus of the left foot All were cured

Of the 66 cases of CDH reported by Krida, Colonna and Carr two bilateral cases were associated with other deformities. One case presented spina bifida and club feet the other a spastic paraplegia. In both of these cases, the dislocation was cured Badgley appears to have been just as successful. In a case associated with bilateral club feet, one hip was reduced by open reduction and a shelf operation was performed In a second case with typical arthrogryposis plus congenital malformation of the sacrum, the femur was pulled down with Kirschner wire traction, preliminary to a second stage operation with reduction in the true acetabulum. Another remarkable case is that described by Compere and Schnute. This was a case of arthrogryposis with bilateral dislocation of the hips and knees and talipes equinovarus deformities. The dislocations were very difficult to reduce. However, after a preliminary period of abduction and traction, the reduction of the dislocated hips was accomplished without undue force

Teratologic cases require the earliest possible treatment. However, owing to the fact that one is usually dealing with puny infants with multiple visible and in addition frequently also invisible abnormalties, primary consideration must be given to the *general condition* of the child Children with gastrointestinal or circulatory disturbances are not suitable for treatment. It is our contention that *cases of this type should first prove their viability before any attempt is made to eradicate their numerous deformities*

Treatment depends upon the degree and the type of the abnormality (p 21) In arthrogryposis, because of the rigidity of the joints present from birth closed reduction of the dislocated hips is out of the question unless one be reconciled to expose the infant to the risk of a fractured thigh. In arthrochalarosis, on the other hand reduction is very easy as a rule, while retention of the joint may prove difficult owing to the congenital flaccidity of the capsule.

The *mode of procedure in treatment* of these cases is to begin with the peripheral deformities (of the hands and feet) and then to proceed proximally to treat the deformities of knees and

elbows and then finally to deal with the hip joint, taking into consideration the peculiarities of the different types of dislocation

In cases of the *arthrogrypotic* group, efforts must be directed first toward resolving the constantly present contractures of the soft parts. In our experience the best results are obtained by conservative methods. The most suitable procedure for this purpose is by wedging in a plaster cast, which has given such good results in the treatment of congenital club feet The foot or knee is placed in a plaster cast and the correction undertaken in stages by excision of corresponding wedges of the cast on the side of the deformity The same procedure can be used for the hands and also for correction of flexion or extension contracture of the knee and elbow Flexion contractures of the wrist are very resistant Since the skin of such children is extremely delicate one must proceed with the utmost caution in order to avoid breaking the skin There are also definite limits determined in particular by the nerves and vessels, which will not tolerate any forcible stretching without grave damage to function and circulation. If the desired correction cannot be obtained by conservative means, surgical methods such as tenotomies or capsulotomy or wedge osteotomies are indicated Only after the feet and knee joints have been corrected in proper sequence may one proceed to reduction of the hip

As stated above, reduction of the dislocated hips by manipulation will as a rule prove futile from the beginning owing to the usually present rigidity of the muscles and capsular adhesions, and a successful result is to be hoped for only following an *open* operation The latter is best attempted towards the end of the first year or in the second year of life. Owing to the fact that there is only slight tendency to progression it is quite safe to postpone treatment for several months in some cases. The indications for open reduction depend upon the momentary conditions, and it is necessary to make a decision in each individual case as to whether the child should be exposed to such a radical intervention or whether it be best to be content for the time being with an improvement in position and then later try one of

the accepted palliative methods. We found subtrochanteric osteotomy a very efficient and safe procedure to establish stability in older cases.

The difficulties encountered are just as great in the combination cases, in which *defects* (of the lower spine, sacrum etc.) are also present, and in which one has to deal also with the deficiency symptoms of the usually irreparable defect In mild cases reduction of the hip may be fairly easy Thus in two cases of bilateral dislocation of the hip combined with *spina bifida occulta*, we successfully accomplished a closed reduction of the hips. Even severe cases may occasionally run a smooth course, as demonstrated in a case described by Joachimsthal in a girl of three years of age, with a defect of the entire left fibula absence of two toes and *corresponding bones of the foot, and dislocation* of the hip on the same side In this case the dislocation was completely cured following closed reduction

After-treatment in the teratologic cases is based on the same principles as for typical dislocation extensive use being made of *the Denis-Browne splint, which maintains the hip joints as well* as the feet in the desired position Some of those cases may require braces and crutches to maintain correction

In cases of *arthrochalarosis* there are other conditions to cope with. Here, as mentioned before, the difficulty lies not in the *reduction of the hip but in maintaining retention*, which so often fails because of the congenital laxity of the capsule In spite of this, we were able to obtain a complete cure in one case in which retention was maintained in a plaster cast for a period of two years. In another case permanent stability was attained *on one side while the other side redislocated immediately* If retention cannot be maintained an attempt at *capsule reefing according to Jones* may be made This is undertaken following reduction of the hip through an incision over the posterior part of the capsule. Pleating of the capsule is accomplished by the 'strap and buckle' method, *i e* by passing a strip of the capsule through a tiny slit in its upper portion This doubles the restraining power of the capsule. Six months fixation of the limb in overextension and slight abduction will then insure retention

On the whole, on must keep in mind the fact that the treatment of teratologic dislocations of the hip constitutes one of the most difficult and frequently insoluble problems of treatment of dislocation None the-less we are of the opinion one should try at least to reduce the disability in all except the most extreme cases as early and as completely as possible. The decision to try one of the methods described above is of course easier when the child is mentally normal, and there are prospects that the child may profit by the results attained. Fortunately teratologic dislocations are extremely rare, so that for this reason alone, the problem of treatment is of less importance than in typical cases.

As regards the other atypical cases, treatment must be suited to the individual case.

In the two *obstetrical* dislocations of the hip associated with fracture of the femur, reported by Elizalde (p 25), the treatment consisted of reduction and immobilization. The Lorenz method of reduction was employed and the limb was fixed in a position of 135° flexion and 40° abduction in slight internal rotation Castex was used for immobilization in preference to ordinary plaster of Paris. The cast was left in situ for 45 days. Both cases were completely cured

In one of our cases of C D H associated with congenital *spastic paralysis* (Little's disease), reduction was successfully accomplished only after subcutaneous tenotomy of the adductors. The cast was applied in abduction of 45° and neutral rotary position In the only case of roentgen injury in our experience (p 25) reduction was fairly easy with moderate force. In this case, the cast was applied in right angled primary position.

Chapter XVII

CONCLUSION

In preparing to draw conclusions from our observations, it is clear, to begin with that considerable advances have been made in the problem of CDH in the last decades. Some recent investigations have clarified the pathogenesis of CDH in many points, and also the question of etiology although not wholly explained, has come closed to a solution The discovery that dysplasia constitutes the primary "anlage in all typical cases of CDH has markedly broadened and deepened our conception of the origin of dislocation The possibility of an early recog nition of this early stage of CDH has opened up new prospects for early treatment

Great progress has been made in treatment in recent years. Unquestionably, many cases have developed a normal or per fect structure of the hip following closed reduction and with the newly acquired knowledge and refinements of technic of open reduction also the surgically treated cases have now a far better outlook than formerly Reconstructive and arthroplastic procedures signify an important step forward in the treatment of CDH And even old irreducible cases, formerly considered hopeless, are now amenable to treatment. However with all due respect to the conquests of modern surgery we cannot ignore the fact that not all cases are cured, and in spite of all the work that has been done, end results continue to fall short of what we thought to accomplish Besides the excellent anatomic and functional results witnessed there are other less favorable is sues. Redislocation is not uncommon following closed as well as open reductions. The thrill of success is very often marred by the development of deformities of the head after reduction Whether these changes may at some time become preventable is a question When however some writers predict 100 per cent cures, as many do this must be attributed to a lack of apprecia tion of the limits of our therapeutic knowledge

On the other hand, it is a fact that in early infancy, it is possible, in the great majority of cases, to *prevent* dislocation if proper prophylactic measures are instituted. The logical deduction, therefore, is to direct our efforts towards administering treatment as soon as possible, before the dislocation has developed i e., within the first year of life To attain this goal, it will be necessary to draw the attention of the medical profession to the early symptoms, so that the condition may be recognized at the earliest possible moment. It is this educational work which constitutes the most important feature of a realistic solution of the problem. Putti stressed the necessity of X-ray examination of the hip in every newborn infant. Such a recommendation would be justified in Italy, where the incidence of C D H is so high. In the United States, where the condition is so rare, however, such a measure would be going too far Nevertheless, in the presence of a family history of C D H, or in infants presenting slight abnormalities, such as flabbiness or outward rotation of the hip, a more thorough examination of the infant, including roentgenography, should be urged If we consider the facilities for roentgenography already available, there is no excuse for omitting this precaution Early diagnosis is imperative if we hope to be successful in eradicating the condition before the pernicious sequelae of the "anlage develop Of course, there will always be some stragglers who have been missed, so that closed and open reduction the shelf operation, arthroplasties and subtrochanteric osteotomies will continue to have their place in the treatment of C D H However it is to be hoped that these operations will become less and less numerous, once prophylactic treatment is no longer a theory, but becomes a practice

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AUTHOR INDEX

S

T

V

W

Z

SUBJECT INDEX

A

R

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By JULIUS HASS M.D

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